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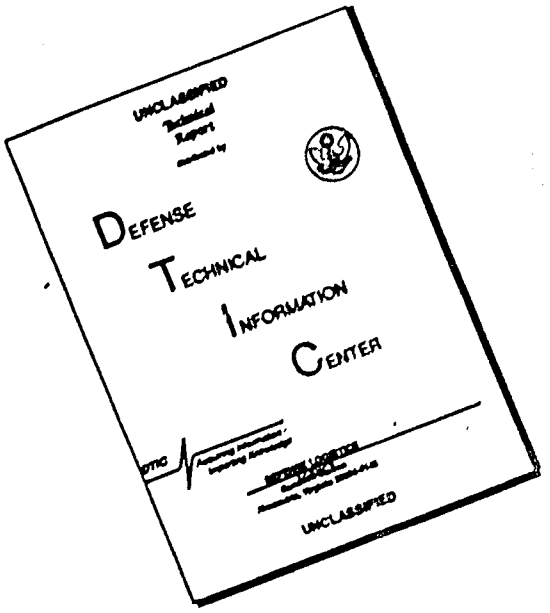

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TECHNICAL REPORT
ES-15

THE YUMA TEST STATION, ARIZONA
HOURLY AND DAILY INSOLATION RECORD
1951-1962

by
IVEN BENNETT PH.D.
Earth Sciences Division

March 1965

U. S. Army Materiel Command
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts

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TECHNICAL REPORT
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THE YUMA TEST STATION, ARIZONA, HOURLY AND DAILY INSOLATION RECORD 1951 - 1962

by

Iven Bennett, Ph. D.
Desert and Tropic Laboratory
Earth Sciences Division

Project Reference:
1V025001A129

March 1965

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FOREWORD

Most published studies of the amount of insolation received at the earth's surface are based on energy received over a period of a day. For many purposes, insolation totaled over intervals of time shorter than a day is required. Daily totals compared over the range of latitude found in the United States actually may provide misleading information for some interpretations. For example, in midsummer, due to the greater duration of daylight in northern latitudes and the higher elevation of the sun in southern latitudes, Alaska and Florida will receive essentially the same daily insolation, although instantaneous intensities for much of the day will be considerably higher in Florida. Because of this, data for short periods of time have considerably more meaning for studies of heat load on humans and for some engineering problems.

This report presents descriptive statistics of hourly and daily insolation for Yuma Test Station, Arizona, an environment in which insolation is often extremely high over short time periods. Yuma is also an environment frequently used by the Department of the Army for testing materiel and personnel under conditions of high ambient temperature and high insolation. The data presented here should be of value to environmental testers and engineers concerned with the design of materiel, and to physiologists responsible for defining the limits of human endurance under conditions of high thermal load.

PEVERIL MEIGS, Ph.D.
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Brigadier General, USA
Commanding

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Approximately 10 years of hourly and daily insolation data for the U. S. Army Yuma Test Station, Arizona are summarized in tabular and graphical form. Frequency distributions, totals and means of hourly and daily insolation, are given for each month of the year.

The data were collected by an Eppley pyrheliometer (horizontal mount) and an electronic strip chart recorder. Integration and reduction of the data to numerical form were done visually. Information is presented concerning the efficiency of the Eppley pyrheliometer, and of the adequacy of visual data integration and reduction.

As expected from the latitude of the station (32°50'N) and the low incidence of cloud cover, insolation values are high throughout much of the year. From March through October, 30 percent or more of the hours receive at least 60 langleys, and from April through August, 20 percent of the hours receive 80 langleys or more. Intensities of 100 langleys or more occur from April through July, with the maximum during May when 3 percent of the 3 hours centered about True Solar Noon reach 100 langleys or more. Low values occur primarily during early morning, or late afternoon hours. Values less than 20 langleys do not occur at midday except on occasional days in winter and during the summer rainy period of late June and July.

Daily values also run high. Daily totals less than 100 langleys occur only in winter and then infrequently. From April through September, only 1.7 percent of the days have totals less than 400 langleys. On the other hand, 53 percent of the days of these same months receive 700 langleys or more.

THE YUMA TEST STATION, ARIZONA, HOURLY AND DAILY INSOLATION RECORD

1. Introduction

Hourly and daily totals of insolation* have been collected at Yuma Test Station, Arizona, from 20 October 1951 to the present time. The data have been gathered as part of a comprehensive meteorological support program provided by the Meteorology Department, U.S. Army Electronic Research and Development Activity, to Department of the Army groups testing Army materiel and personnel at Yuma. In this report a climatic summary is presented of certain features of the record from 20 October 1951 through 31 March 1962. Emphasis is on tabulations of descriptive statistics, and especially on frequency distributions of hourly and daily values of insolation.

Throughout the period of record, the sensor has been an Eppley pyrheliometer (mounted horizontally). Data recording has been by an electronic strip chart recorder.

The following information concerning instrumentation and its location was provided by the Yuma Meteorological Team.

> The first data were collected near Building #822 on "Main Post" in a representative area. No instrumentation data are available. Radiation equipment was moved to the "R & D Area" about 1 January 1954. The Eppley pyrheliometer #2297 was then located 430 feet southwest of Building #2700 and 5 feet above the ground. On 19 January 1959, pyrheliometer #3601 was installed on a post 4 feet above the platform on the roof of Building #2700 and 27 feet above the ground (see Fig. 1). Location of the sensor remains the same to date. Exact dates of change are unknown but during 1960 #2293 was used and from 1961 to April 1963 #3554 was used. It is known that #3554 was recalibrated on 3 February 1961.

---

* In this study, the term "insolation" refers to the total radiant energy from the sun incident on a unit area of a horizontal plane located at the surface of the earth. It is expressed in langleys (1 ly = 1 gm cal/cm^2/min). It is equivalent to the term "global radiation" (Globalstrahlung) used by many European investigators. It includes all energy in the wavelengths emitted by the sun (approximately 0.1 to 7.0 μ) reaching the bottom of the atmosphere in the direct solar beam and in diffuse sky radiation scattered from the solar beam. It also includes any increment to this total from energy scattered back to the ground by multiple reflection between the ground and the sky or clouds. It does not include energy received at the earth's surface in infrared wavelengths generated by the kinetic energy of molecules of atmospheric gases and particulate matter.

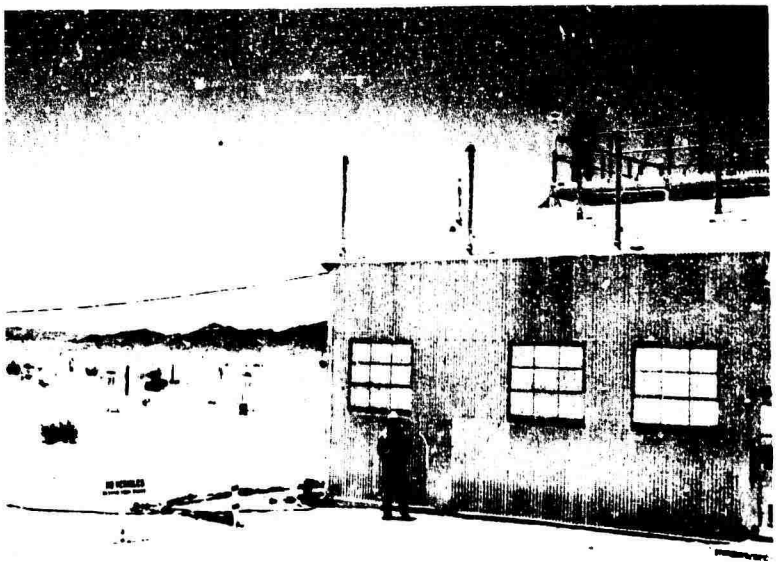


Figure 1. Location of Eppley Pyrheliometer at Yuma Test Station, Arizona

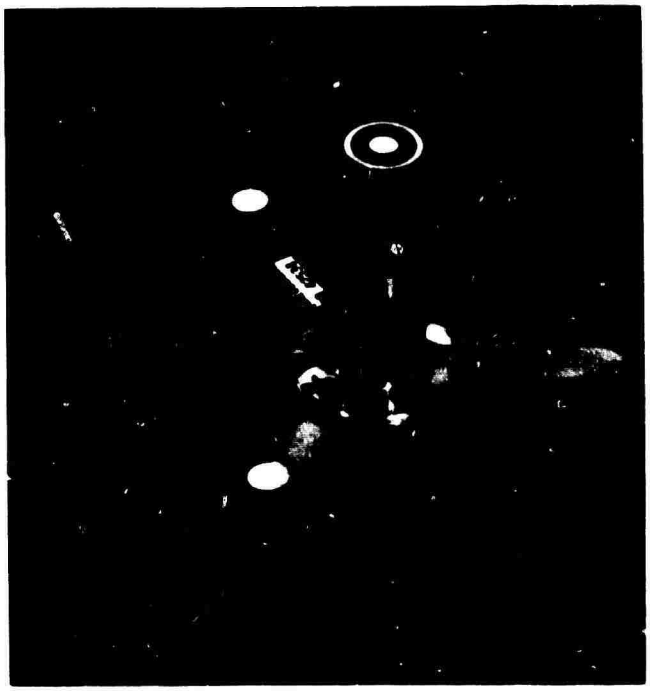


Figure 2. Close-up of Eppley Pyrheliometer

While the pyrheliometer was located on the "Main Post" it was 207 feet above mean sea level. In the "R & D Area" it was first at 325 feet msl, then at 346 feet msl where it remains at present. The approximate latitude and longitude of the instrument during the entire period of record has been 32°50'N and 114°24'W.

2. Instrumentation and Data

a. The Eppley Pyrheliometer

The Eppley pyrheliometer merits a brief description of its general characteristics and of certain sensing and recording difficulties.

Until very recently, no completely reliable system of a non-laboratory nature had been developed for measuring and recording insolation, or for reducing the recorded measurements to digital form*. All insolation data used in the present study were collected by the system used by the United States Weather Bureau, consisting of an Eppley pyrheliometer, an electronic strip-chart recorder, and visual integration of the data. The reliability of this system is typical of most used throughout the world, furnishing, if operated properly, hourly and daily data with an average error of 10 percent or less.

The Eppley pyrheliometer (see Fig. 2) is a thermopile-type instrument that measures insolation by noting the temperature difference created by radiant energy striking a receiving surface consisting of two concentric silver rings, an inner ring covered with lampblack which absorbs virtually all incident insolation, and a white outer ring coated with magnesium oxide with a very high coefficient of reflection for energy in the wavebands of insolation.** Both rings are enclosed in a hermetically sealed spherical glass bulb 3½ inches in diameter. Mounted on the under sides of the rings is the thermopile made up of either 10 or 50 thermocouples. The hot junctions are attached to the black-surfaced disc, the cold junctions are attached to the white-surfaced disc, and the difference in temperature between these junctions generates a small flow of electrons proportional to the intensity of insolation falling on the sensing surfaces.

The spectral response, approximately 0.3 to 5.0μ, of the Eppley to solar energy is due principally to the transmission characteristics of

---

* The Eppley Company, together with the manufacturers of electronic recorders, has recently developed a system that more closely approaches the ideal. This system was not available for use at Yuma and none of the comments in this section apply to it.

** The physical description of the instrument given here is taken from Eppley Laboratory, Inc., Bulletin No. 2.

the glass used in the bulb. The glass, however, is not controlled for constant transmissivity, and bulbs may vary slightly from one another in the extent of this range. The percent of transmission of the glass varies considerably within the 0.3 to 5.0μ range. It is lowest and approaches zero at either end of the range and highest (above 90 percent) between 0.4 and 2.6μ where nearly all the energy in insolation is found. On the ultraviolet end the transmission falls rapidly from close to 100 percent at 0.4μ to less than 5 percent at 0.28μ, while through the infrared region transmission remains about 70 percent to about 4.2μ, after which it declines sharply toward values approaching zero just beyond 5.0μ.

Laboratory tests have been conducted by several individuals to determine the nature and extent of other errors in the performance of the instrument. One such error involves variations in response with departure of ambient air temperature from the temperature of calibration, 80°F. According to the physical principles governing the electrical output of the thermopile, the output should increase with the ambient temperature. However, the response actually decreases slightly with increasing temperature (MacDonald, 1951, pp. 158-159). Table I, adapted from MacDonald, shows the results of temperature tests with 7 different instruments. The decrease in response with temperature increase above 80°F and conversely, the increase with temperature decrease below 80°F, are apparent. The changes are by no means uniform from instrument to instrument, though they do fall rather closely together. Within the maximum range of temperature normally expected at Yuma, from 40°F to 120°F, the error is less than 4 percent for all the instruments tested.

TABLE I
EFFECT OF AMBIENT TEMPERATURE ON PERFORMANCE OF EPPLEY PYRHELIOMETERS*
(RESPONSE IS GIVEN IN PERCENT OF RESPONSE AT 80°F)

Ambient Temp. (°F.)	Pyrheliometer**							
	#1617	#1654	#1830	#1973	#1977	#1220	#1221	Mean
-40	106.2	102.7	103.1	105.4	----	108.1	103.3	104.8
0	105.2	102.5	102.7	106.5	105.1	105.5	102.4	104.3
40	102.4	101.1	101.1	104.1	103.0	102.8	101.4	102.3
80	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
120	96.2	99.0	97.3	97.0	96.4	96.7	97.8	97.2

* After a table by MacDonald, 1951, p. 155.
** Data are given for 7 pyrheliometers, numbered as in column headings.

Another error that must be considered is the so-called cosine error. As the zenith angle of a beam of radiant energy striking the receiving surface of the instrument moves from 0° (normal to the receiving surface) to 90°, assuming constant energy in the beam and no change in other conditions affecting the response of the instrument, the output of the thermopile should decrease with the cosine of the zenith angle, or from 100 percent of the energy in the beam when the sun is directly overhead to 0 percent when the sun is on the horizon. Laboratory tests by several individuals have shown that this is seldom the case. With low angles of incidence, the instrument generally indicates amounts of insolation that are too small. Miller (1942, p. 324) has suggested as a factor changing coefficients of reflection and absorption, with changing angles of incidence, of the materials used to coat the sensing surface. Woertz and Hand (1941, p. 148) believe the black and white surfaces might not be precisely in the same plane, and that the surfaces might be slightly curved; either of these could cause a variation in response with different angles of incidence. They also discovered that inaccuracies in leveling the surface of the receiver during mounting for field service could contribute to a cosine error of 3.6 percent with zenith angles of 70° or more. Kimball and Hobbs (1923, p. 242) pointed out that the glass envelope could contribute to cosine error unless it was exactly spherical and free from flaws of all kinds.

To give valid data, the Eppley requires constant attention. It is especially important to prevent the accumulation on the outside of the glass bulb of materials such as dust that will cut down transmission of energy to the receiving surface. Dust collection was bound to have been a problem at Yuma, particularly during one period when the instrument was located only 3 or 4 feet above ground level.

A very serious source of possible error involves the electronic recorder used to amplify and record the signal from the pyrheliometer. These recorders are complex and sensitive instruments that require constant expert care to insure proper performance. It is possible for them to drift slowly out of calibration at a rate that would at first escape visual detection. In the present study, many days of data had to be eliminated because values were obviously too high, most likely due to a faulty recorder, and unquestionably much inaccurate data that were not noticeably high or low were left in the study.

A final source of error is produced by the method used to reduce the data to digital form from the line traced by the recorder. Figure 3 contains reproductions of charts similar to those traced at Yuma. In order to calculate the insolation received during any time period on the chart, the area under the curve must be integrated. This is done by eye and involves estimating the mean elevation of the insolation curve for the period in question. Ten-minute periods were used at Yuma, with the values

for these added together to get hourly totals. On an essentially clear day, as shown in Figure 3b, the estimate should be accurate if made with care. On a day with rapidly fluctuating cloud density, Figure 3a, the estimation process becomes very difficult and uncertain. Fortunately, Yuma has a high percentage of clear or nearly clear days; therefore this source of error is held to a minimum.

b. Mountain Standard Time vs. True Solar Time

In the analysis of hourly data for this study, the record has been divided into two periods: (1) 20 October 1951 through 30 September 1958, during which time hourly data were summarized according to Mountain Standard Time; and (2) 1 October 1958 through 31 March 1962, when True Solar Time was the basis for summarization. Hourly data for these two periods are not comparable, since True Solar Noon varies throughout the year in relation to the Standard system. This, of course, does not affect daily insolation values; consequently they have been analyzed for the entire period from 1951 through 1962.

c. International Pyrheliometric Standard of 1956

Effective 1 October 1958, the pyrheliometer at Yuma was recalibrated to conform to the International Pyrheliometric Standard of 1956. Before this, calibration was according to the Smithsonian Standard of 1913. The 1956 standard gives values 2 percent lower than those of the earlier one. Hence in order for all data of the period of record to conform to the 1956 standard, hourly and daily values before 1 October 1958 were reduced by 2 percent.

3. The Yuma Test Station Climate

Yuma Test Station is located in extreme southwestern Arizona in one of the hottest and driest parts of North America. Summers are long and hot, with four months, June through September, having mean daily maximum temperatures above 100°F, and that of July rising to 108°F*. Winters are warm with occasional light frosts. Annual rainfall averages only 3.4 inches. The area lies too far south to benefit appreciably from the winter rains of storms originating in the north Pacific Ocean and too far west to gain much from the summer rains associated with moist air from

* All climatic data cited in this discussion are for the Yuma Weather Bureau Airport Station, located 17 miles southwest of the Test Station instrument site. Although climatic data are available for the Test Station, those of the Weather Bureau station are for a considerably longer period of time and are available in summary form. A comparison of some data for the two stations (Nelson, 1957) indicated there is little difference between their climates.

DAILY INSOLATION TRACES FROM EPPLEY PYRHELIOMETER

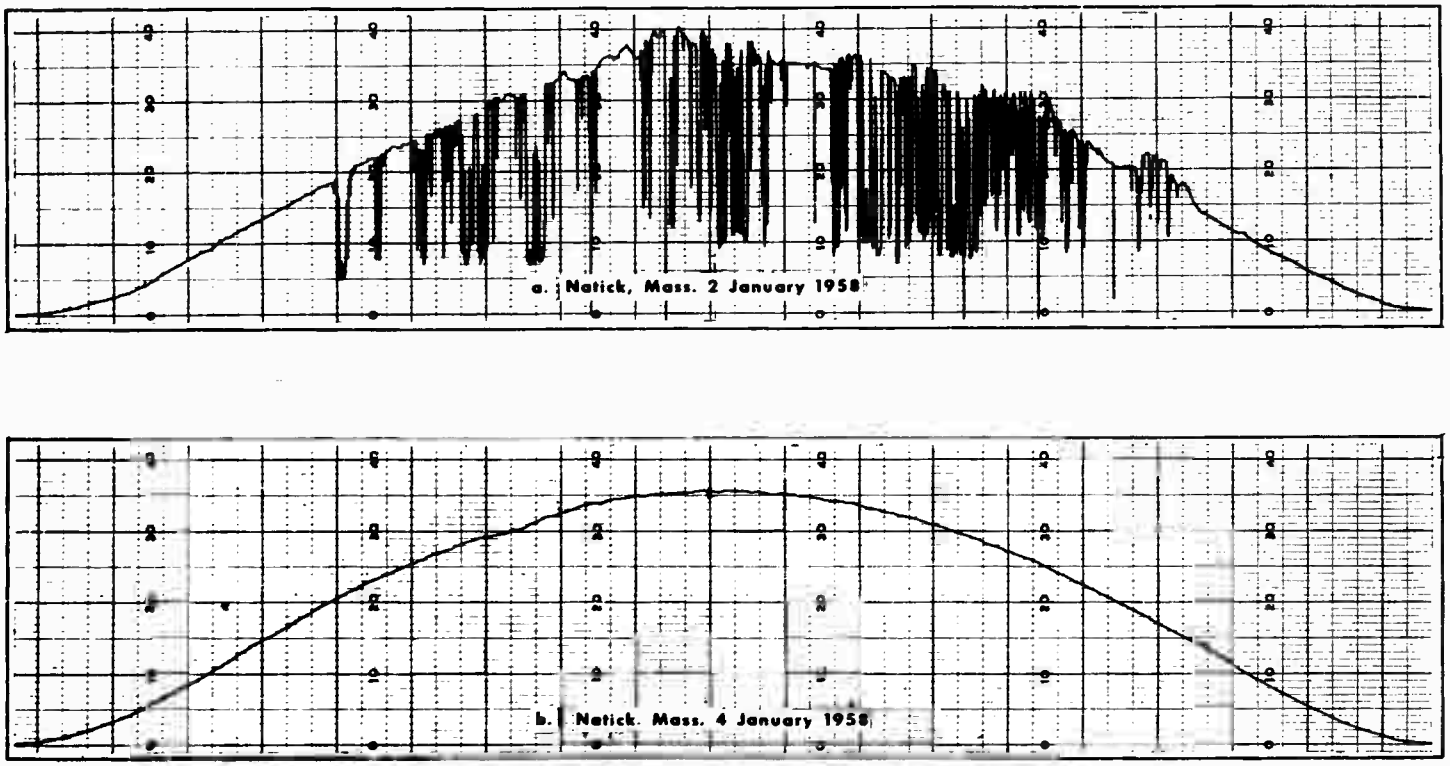


Figure 3

the Gulf of Mexico. September and December receive the most rain, occurring as nighttime thundershowers in September and light continuous rain in December. May and June are the driest months, averaging 0.02 and 0.01 inch respectively.

Most arid areas, though certainly not all, have a low incidence of cloud cover and receive almost the maximum of possible sunshine and insolation. Yuma is not an exception to this. Mean annual cloud cover from sunrise to sunset is only 0.25, and 93 percent of the possible sunshine is received. Much of the cloud cover consists of thin alto-cumulus, alto-stratus or cirrus clouds that intercept only a small part of incoming solar energy. Maximum cloud cover occurs during the winter months. Monthly mean daily values for December, January, February and March are 0.34, 0.43, 0.32 and 0.34 respectively. June and September have the least cloud cover, 0.12 for each. A slight secondary maximum is found during July and August, with both months averaging 0.23.

The percent of possible sunshine received is high during the entire year. The monthly mean daily value for the least sunny month, January, is 85 percent. All other months, except December with 87 percent, have mean daily values of 90 percent or higher. May, June and September are the sunniest months with mean daily values of 97, 98 and 97 percent. Of the 126 months covered by the present report, 91 percent received 80 percent or more of the possible sunshine and 69 percent received 90 percent or more. Two months, June 1955 and May 1957, received 100 percent of the possible sunshine. Only one month, January 1957 with 64 percent of the possible sunshine, received less than 75 percent.

Days with solid, thick overcast skies that reduce insolation to very low values (100 to 150 ly per day) are rare, whereas completely clear days are common. For the year as a whole Yuma has 6.6 times as many clear as overcast days (Sellers, 1958, p. 23), and many of the overcast days have high, thin clouds that permit passage of considerable solar energy to the earth's surface.

4. Presentation of the Data

a. Validity of 1951-62 Data for Climatic Analysis

The period of record (1951-1962) on which this study is based is relatively short for climatic purposes, hence it would be valuable to determine if the climate during the period of the study is representative of that of a considerably longer period. To make the comparison meaningful to the purpose of this study it is necessary to use climatic elements that correlate highly with insolation. For this purpose, monthly mean daily values of cloud cover and percent of possible sunshine were selected. Figure 4 shows how monthly mean values of these two elements for 1951-1962

COMPARISON OF SUNSHINE AND CLOUD COVER MONTHLY MEAN DAILY VALUES FOR 1951 - 1962 WITH VALUES FOR 1921 - 1950

U.S. WEATHER BUREAU AIRPORT STATION, YUMA, ARIZONA

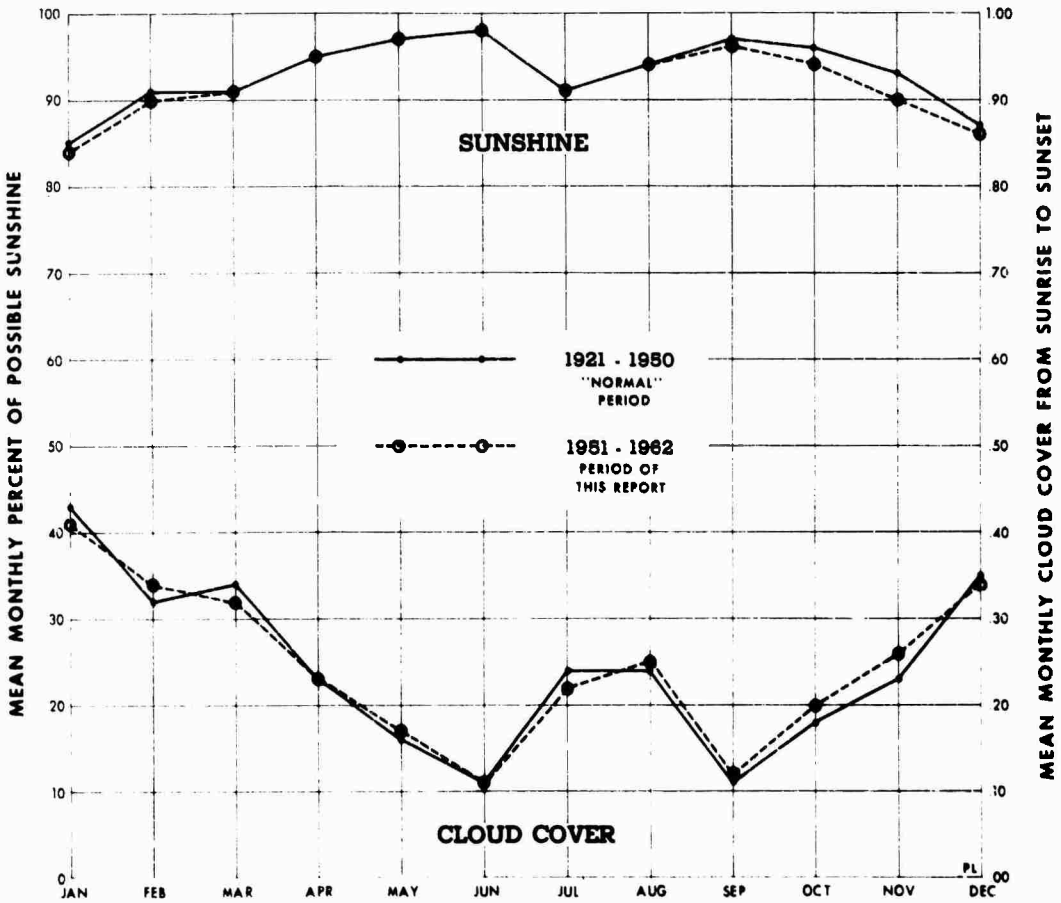


Figure 4

for the Yuma Weather Bureau Airport Station compare with those of 1921-1950 for the same station. The period 1921-1950 is used by the United States Weather Bureau as a base for establishment of climatic normals. It is apparent that values of the two periods match closely and that insolation statistics for 1951-1962 can be considered reasonably representative of statistics for much longer periods of time.

b. Hourly Insolation Data

The hourly insolation data for Yuma Test Station are summarized in Tables II-IV and Figures 5-8. Through examination of Tables II and III,* the occurrence for any hour in any month of insolation in specified classes of 10 langleys can be determined. Also, by adding percentage frequencies the probability of occurrence above, below, or between certain insolation levels can be estimated.

As expected from the low incidence of cloud cover, hourly insolation values are high throughout much of the year. The 1951-1958 data (Table II) show that from March through October, 30 percent or more of the hours receive at least 60 langleys of insolation. This is a large quantity of radiant energy, equivalent to 1.0 ly per minute, or half the solar constant. From April through August, 20 percent or more of the hourly values are at 80 ly or over. Intensities of 100 ly or more occur from April through July, with the maximum during May when 3 percent of the 3 hours (1200, 1300, 1400)** centered about True Solar Noon reach 100 ly or above. Low values also occur, but primarily during early morning or late afternoon hours when the sun is low in the sky. Low values of 20 ly occur at midday only on occasional days in winter and during the summer monsoon period of late June and July when moist tropical air from the Gulf of Mexico invades the area and causes midday cloudiness.

When all of the hours for a month are considered together, the frequency distribution is generally bimodal (Fig. 5). The two peaks of the distribution are located at or near the extremes of the distribution. This is because there are more hours with low sun and high sun respectively than with intermediate sun, and there is little cloud cover during the day to mask this sun control.

The totals and means of hourly insolation for each year of the period of record are given in Table IV. Means of the 3 high sun hours (1200, 1300, 1400) are 67 ly or higher, even though data from the winter season have been included in their computation. For the 7 hours ending 1000

* Tables of frequency distribution for each month (Tables II and III) are at the end of this report.

** All hourly data are for the hour ending.

TABLE IV

YEARLY TOTALS AND MEANS OF HOURLY INSOLATION IN LANGLEYS
Yuma Test Station, Arizona
1952 - 1961

Hour Ending

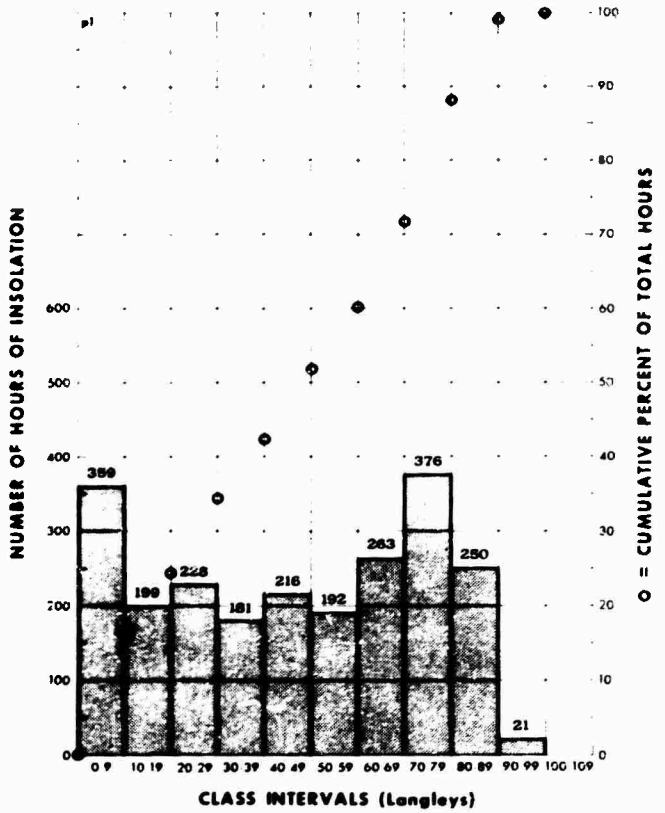
YEAR	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21
1952																
Total	60	1085	4174	9333	14581	18842	21580	22414	21772	19665	15872	10696	5514	1931	240	0
Mean	0	3	13	30	47	60	69	72	70	63	51	34	18	6	1	0
1953																
Total	30	982	4461	10311	16480	21284	24419	25669	25355	22912	18554	12582	6483	2105	240	0
Mean	0	3	13	30	48	62	71	74	73	66	54	36	19	6	1	0
1954																
Total	23	1150	4832	10767	16616	21737	24996	26196	25379	22732	18619	12770	6693	2250	269	0
Mean	0	3	14	31	48	62	72	75	73	65	53	37	19	6	1	0
1955																
Total	36	1430	5525	11314	17054	21595	24614	25752	25069	23097	18698	13277	7268	2580	354	1
Mean	0	4	17	34	51	65	74	77	75	69	56	40	22	8	1	0
1956																
Total	68	1476	5234	10773	16383	21027	24007	25248	24761	22374	18102	12685	6782	2334	279	0
Mean	0	5	16	33	51	65	75	78	77	69	56	39	21	7	1	0
1957																
Total	86	1178	4157	9140	14047	17946	20699	21585	21017	18754	15067	10443	5605	1978	267	2
Mean	0	4	14	30	46	59	68	71	69	61	49	34	18	6	1	0
1958*																
Total	19	975	4910	10746	16323	20571	22929	23566	22618	19843	15695	10322	5410	1793	163	1
Mean	0	3	15	34	51	64	72	74	71	62	49	32	17	6	1	0
1959																
Total	153	1896	6560	12585	18328	22657	24749	25288	23811	20210	15405	9384	4050	913	55	0
Mean	0	5	18	35	51	64	70	71	67	57	43	26	11	3	0	0
1960																
Total	194	2008	6510	12402	17954	22031	24598	25052	23576	20422	15437	9460	4170	931	31	0
Mean	1	6	18	35	51	62	69	71	67	58	44	27	12	3	0	0
1961																
Total	232	2318	6774	12491	17999	22024	24412	24947	23581	20544	15704	9874	4518	1161	49	0
Mean	1	7	20	37	54	66	73	75	71	62	47	30	14	3	0	

NOTE: FROM THE BEGINNING OF THE RECORD THROUGH SEPTEMBER 1958 THE HOURS ARE FOR MOUNTAIN STANDARD TIME.
FROM OCTOBER 1958 TO THE END OF THE RECORD THEY ARE TRUE SOLAR TIME.

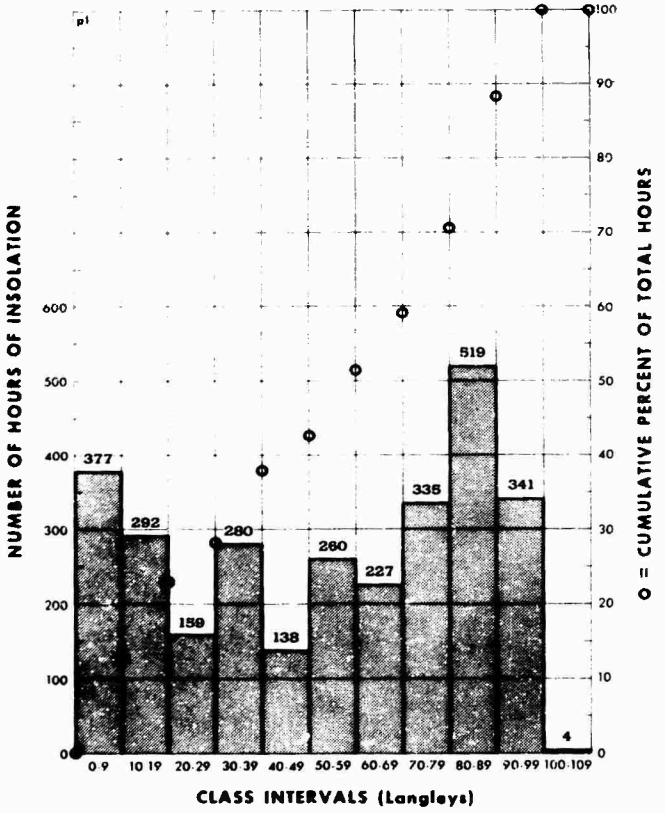
HISTOGRAMS OF HOURLY INSOLATION

YUMA TEST STATION, ARIZONA

a. MARCH 1952 - 1958



b. JUNE 1952 - 1958



HISTOGRAMS OF HOURLY INSOLATION

YUMA TEST STATION, ARIZONA

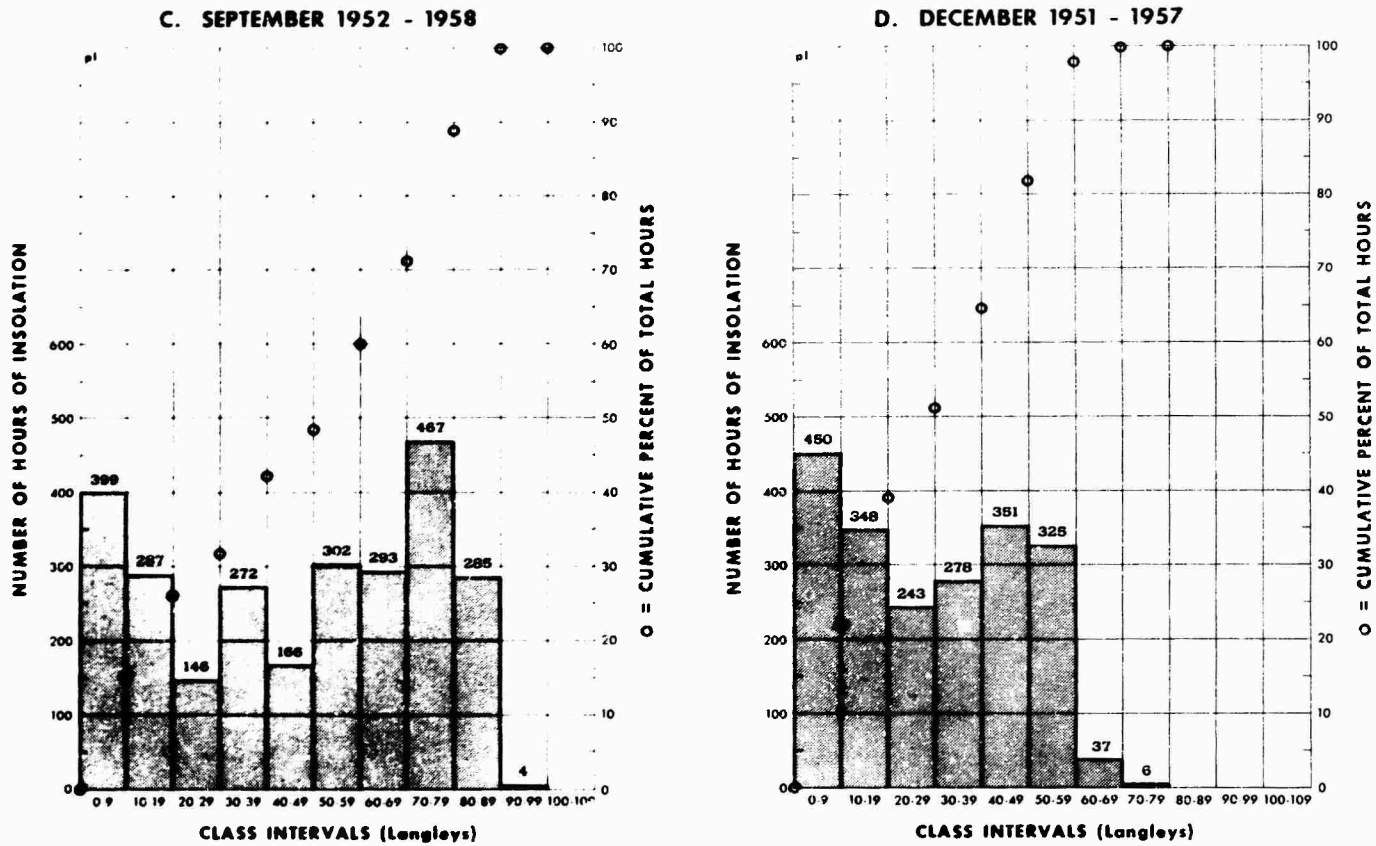


Figure 5

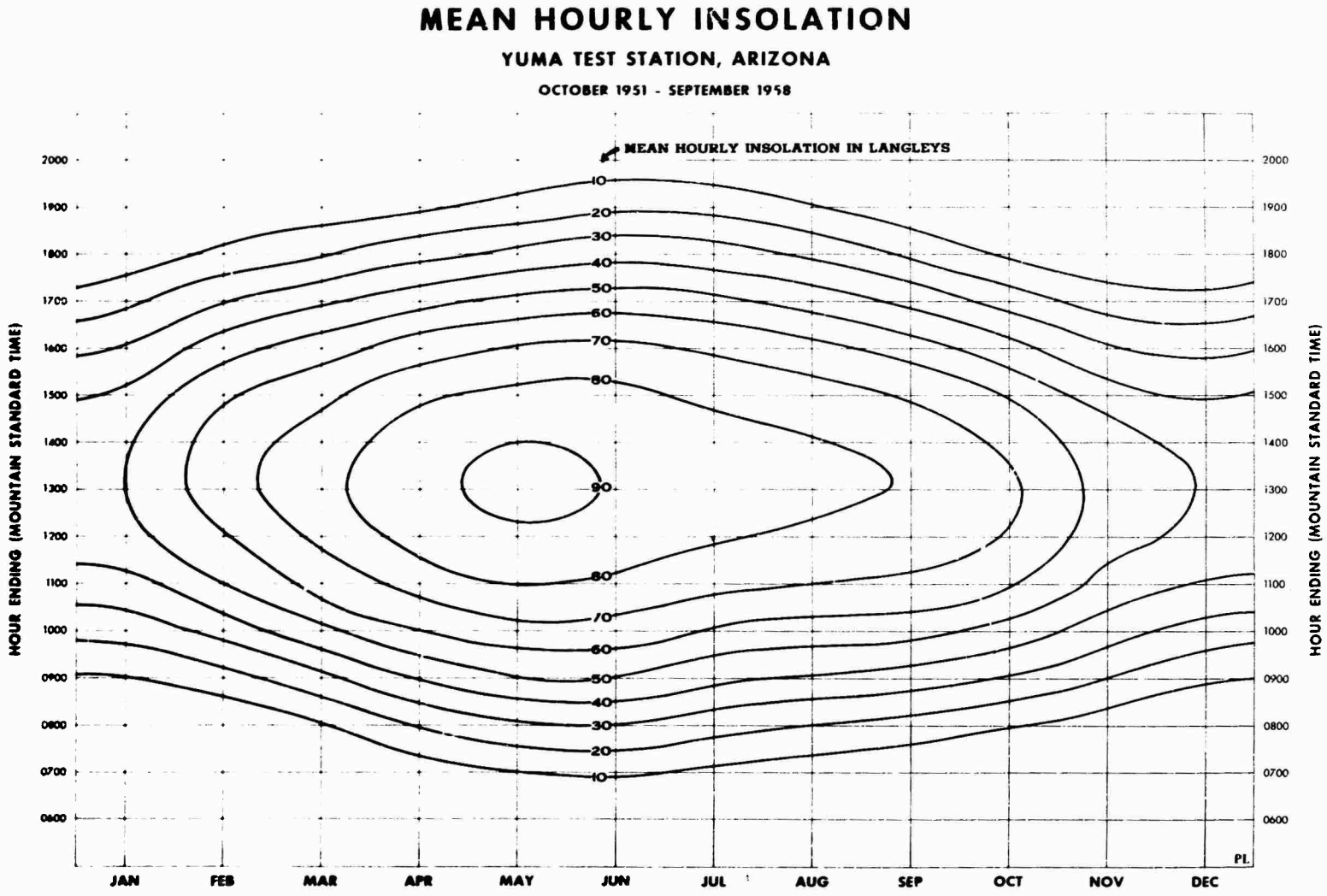

MEAN HOURLY INSOLATION
YUMA TEST STATION, ARIZONA
OCTOBER 1951 - SEPTEMBER 1958
MEAN HOURLY INSOLATION IN LANGLEYS
10
20
30
40
50
60
70
80
90
80
70
60
50
40
30
20
10
HOUR ENDING (MOUNTAIN STANDARD TIME)
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
0900
0800
0700
0600
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
PI.

Figure 6

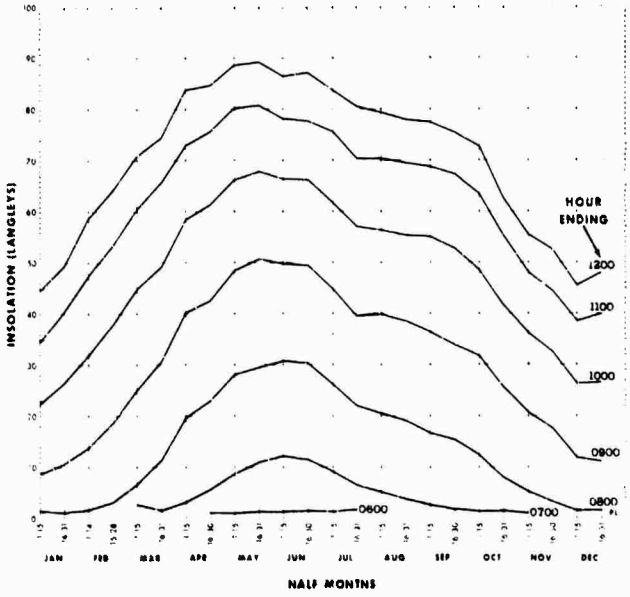
MEAN HOURLY INSOLATION FOR HALF MONTHS

YUMA TEST STATION, ARIZONA

a. MORNING HOURS

(MOUNTAIN STANDARD TIME)

OCTOBER 1951 - SEPTEMBER 1958



b. AFTERNOON HOURS

(MOUNTAIN STANDARD TIME)

OCTOBER 1951 - SEPTEMBER 1958

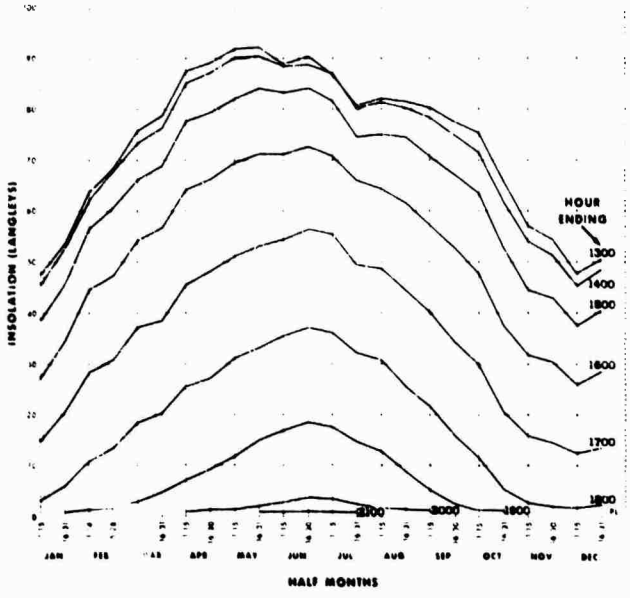


Figure 7

COMPARISON OF DISTRIBUTION OF YUMA HOURLY INSOLATION WITH THAT OF VARIOUS STATIONS

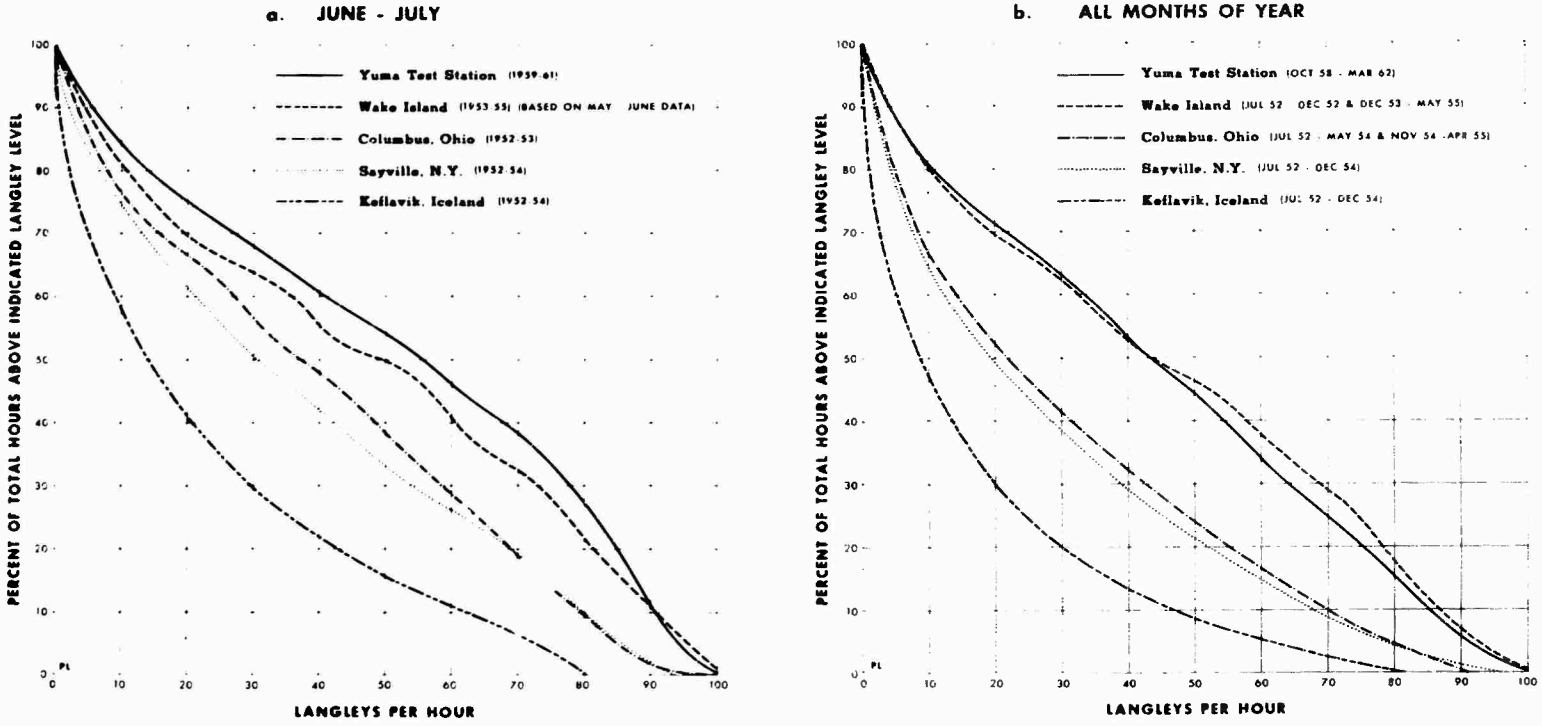


Figure 8

through 1600, means are 43 ly or higher. Finally, it can be pointed out that all hours show a uniformity of means from year to year, indicating a high degree of stability of the insolation climate.

Another summary of hourly data is presented in Figure 6, in which the mean insolation of each hour (Mountain Standard Time) by months for the period 1951-1958 are presented. The hour ending 1300 receives the greatest insolation throughout the year. For this hour the mean falls below 50 ly only during December when it is 49.4 ly. The 1300 mean lies above 60 ly from February through October, above 70 ly from March through October, and above 80 ly from April through August, and close to or above 90 ly from May through June. The three hours with highest values average close to 80 ly or more from April through August. Sixty ly is encountered as early in the day as 1000 and as late as 1600 from April to July. The symmetrical arrangement of the isolines about the hour ending 1300 is due to the low incidence of cloud cover and strong sun control at Yuma.

In Figure 7, the annual course of hourly mean insolation is shown for half-month periods. Of interest is the fact that for high sun hours the maximum values occur during the half month 16-31 May, but with the sun lower in the sky during both morning and afternoon the maximum shifts to the first or even the second half of June. For most hours, a dip in values beyond that expected from solar control is indicated for the half month 16-31 July during which time the influx of moist tropical air and associated cloud cover is most pronounced.

Yuma hourly insolation for June-July and the entire year is compared with that of Columbus, Ohio; Sayville, New York; Keyflavik, Iceland; and Wake Island in Figure 8. From Figure 8a it can be seen that during the high sun period (June and July) Yuma values are considerably higher than those of Keyflavik and of the two United States stations, and slightly above those of Wake Island. This is true of Wake Island even though the sun is higher in the sky at Wake during the "high sun" period. From the curves for all months shown in Figure 8b, Yuma again ranks considerably above Keyflavik and the two United States stations and very close to or only slightly below Wake Island. Yuma ranks below Wake Island because of the higher average annual height of the sun at Wake.

c. Daily Insolation Data

The monthly totals and means of daily insolation for every month from January 1952 through December 1962, and the totals and means for each year, and the period of record are presented in Table V.

Table VI contains daily frequency data tabulated by months in class intervals of 50 ly. As with the hourly data, values run high. Daily totals less than 100 ly occur only in winter and then infrequently. Values less than 100 ly represent energy received on heavy overcast days and have

TABLE V

MONTHLY TOTALS AND MEANS OF DAILY INSOLATION IN LANGLEYS
Yuma Test Station, Arizona
1952 - 1962

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1952													
No. Days	31	29	13		31	30	30	28	30	30	29	31	312
Total	8250	12238	7300		23525	24056	21945	18697	17447	14437	10441	9463	167759
Mean	266	422	562		759	802	732	666	582	481	360	305	538
1953													
No. Days	31	28	27	28	28	29	27	31	27	31	30	28	345
Total	10810	12803	15166	18835	21163	21866	17463	21081	16649	15106	11321	9604	191867
Mean	349	457	562	673	756	754	647	680	617	487	377	343	556
1954													
No. Days	31	28	30	30	31	29	30	31	27	24	28	30	349
Total	10354	12833	15621	20793	23060	22454	20352	21282	16189	11554	11444	9093	195029
Mean	334	458	521	693	744	774	678	686	600	481	409	303	559
1955													
No. Days	31	27	28	30	31	30	30	31	30	27	26	13	334
Total	10096	12646	16998	20856	23752	24219	22031	20267	19124	13772	9964	3929	197654
Mean	326	468	607	695	766	807	734	654	637	510	383	302	592
1956													
No. Days	31	29	28	30	31	27	27	31	30	23	16	19	322
Total	9643	13614	16991	20721	24016	20669	19536	22695	18622	11827	6612	6587	191533
Mean	311	469	607	691	775	766	724	732	621	514	413	347	595
1957													
No. Days	28	25	30	25	29	27	29	25	29		27	31	305
Total	8435	10466	16045	17330	21705	21296	20999	12381	15425		8238	9650	161970
Mean	301	419	535	693	748	789	724	495	532		305	311	531
1958													
No. Days		27	31	28	27	29	29	30	30	31	29	29	320
Total		10927	15759	18655	20924	20424	20447	19094	16696	14068	9877	9013	175884
Mean		405	508	666	775	704	705	636	556	454	340	311	550
1959													
No. Days	29	27	30	29	29	30	31	31	30	31	30	29	356
Total	9936	10701	16761	18621	20885	21905	19527	18631	17285	14361	10117	7314	186044
Mean	343	396	559	642	720	730	630	601	576	463	337	252	523
1960													
No. Days	31	29	30	30	25	26	31	31	30	31	30	30	354
Total	9606	11704	16439	19562	18082	18994	21445	18942	14563	8112	10311	9229	176989
Mean	310	404	548	652	723	730	692	611	485	262	344	308	500
1961													
No. Days	31	28		30	31	30	31	31	30	31	30	31	334
Total	9683	12876		20664	24210	23829	22270	20406	18685	15207	10049	8749	186628
Mean	312	460		689	781	794	718	658	623	490	335	282	559
1962													
No. Days	31	28	31	30	31	30	31	31	30	31	30	30	364
Total	10680	10881	17346	20752	24100	24391	22276	21088	17037	15211	10451	8723	202936
Mean	344	389	560	692	777	813	719	680	568	491	348	291	558
1952-1962													
No. Days	305	305	278	290	324	317	326	331	323	290	305	301	3695
Total	97493	131689	154426	196789	245422	244103	228291	214524	187722	133655	108825	91354	2034293
Mean	320	432	555	679	757	770	700	648	581	461	357	304	550

TABLE VI

FREQUENCY DISTRIBUTION OF DAILY INSOLATION IN LANGLEYS FOR EACH MONTH OF THE YEAR
Yuma Test Station, Arizona
20 October 1951 - 31 March 1962

Class Intervals in Langleys

Month	No. of Days	00 to 49	50 to 99	100 to 149	150 to 199	200 to 249	250 to 299	300 to 349	350 to 399	400 to 449	450 to 499	500 to 549	550 to 599	600 to 649	650 to 699	700 to 749	750 to 799	800 to 849	850 to 899	900 to 949
Jan	305		7 2.3	8 2.6	15 4.9	21 6.9	39 12.8	79 25.9	103 33.8	30 9.8	2 0.7	1 0.3								
Feb	305		1 0.3	1 0.3	5 1.6	9 3.0	13 4.3	17 5.6	32 10.5	73 23.9	99 32.5	48 15.7	7 2.3							
Mar	308			1 0.3	1 0.3	4 1.3	4 1.3	4 1.3	10 3.2	8 2.6	21 6.8	58 18.8	92 29.9	82 26.6	21 6.8	2 0.6				
Apr	260						1 0.4		2 0.8	3 1.2	6 2.3	4 1.5	9 3.5	28 10.8	88 33.8	101 38.8	18 6.9			
May	293											4 1.4	3 1.0	5 1.7	20 6.8	77 26.3	135 46.1	46 15.7	2 0.7	1 0.3
Jun	287				2 0.7					2 0.7	1 0.3	1 0.3		4 1.4	14 4.9	64 22.3	96 33.4	102 35.5	1 0.3	
Jul	295				2 0.7	1 0.3		1 0.3	5 1.7	5 1.7	6 2.0	8 2.7	8 2.7	19 6.4	52 17.6	82 27.8	81 27.4	25 8.5		
Aug	300				1 0.3	1 0.3	1 0.3	3 1.0	3 1.0	7 2.3	4 1.3	17 5.7	23 7.7	57 19.0	103 34.3	67 22.3	12 4.0	1 0.3		
Sep	292			1 0.3			2 0.7	2 0.7	2 0.7	4 1.4	8 2.7	29 9.9	107 36.6	95 32.5	38 13.0	4 1.4				
Oct	271				1 0.4	5 1.8	5 1.8	5 1.8	19 7.0	38 14.0	95 35.1	79 29.2	21 7.7	2 0.7	1 0.4					
Nov	305		1 0.3	2 0.7	10 3.3	15 4.9	35 11.5	65 21.3	102 33.4	66 21.6	9 3.0									
Dec	301		8 2.7	12 4.0	9 3.0	28 9.3	52 17.3	142 47.2	46 15.3	3 1.0	1 0.3									
Year	3,522		17 0.5	25 0.8	46 1.3	84 2.4	152 4.3	318 9.0	324 9.2	239 6.8	252 7.2	249 7.1	270 7.7	292 8.3	337 9.6	397 11.3	342 9.7	174 4.9	3 0.1	1 0.1

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF DAYS;
THE LOWER REPRESENTS THE PERCENT OF DAYS.

virtually no warming effect on the earth's surface or the atmosphere under the cloud layer. At Yuma, only slightly more than 1 day in 100 can be expected to have less than 100 ly total insolation during the winter months (November through February). During summer, low values are seldom seen. For example, from April through September, only 1.7 percent of the days have totals less than 400 ly. On the other hand, 53 percent of the days of these same months receive 700 ly or more. This is truly a massive amount of energy and explains in large part the high daily maximum temperatures, frequently above 100°F, of these months.

Period-of-record monthly means, absolute maxima and minima and certain percentiles (5, 25, 50, 75, 95) of daily insolation are shown in Figure 9. Also presented is the percent of total daily values occurring above the mean. With respect to this percentage, 6 months have 60 percent or more of the days with values larger than the mean, and for all 12 months the figure is in excess of 50 percent. Hence it is not possible to assume, as is so often done, that the mean is a guide to the 50th percentile or median. Also of interest is the considerably smaller frequency range for May than for the other high sun months (June and July). This smaller range is brought about by the complete absence of values below 517 ly during May, whereas the other months experienced at least an occasional day with insolation total less than 200 ly. The frequent occurrence of days with unusually high insolation totals during the high sun season is brought out by the following 75th percentiles for April through August: April, 726 ly; May, 790 ly; June, 814 ly; July, 769 ly; and August, 703 ly.

The annual march of daily insolation is presented in Figure 10. Small dots have been placed on the diagram representing the total insolation for each day of the period of record. For comparison, the daily extraterrestrial insolation has been plotted (large dots) for selected days. The distribution of the dots clearly shows the high frequency at all times of the year of values near the maximum possible. Late April and May stand out as a time when low daily totals simply do not occur. Testing under conditions of high thermal load could be done at this time of the year with virtually no danger of interruption due to cloudy weather.

5. Acknowledgments

Many individuals assisted in the preparation of this report. Mrs. Phyllis Tierney, and Mr. James Hawkins, Computer Branch, respectively, punched the data on cards and supervised the machine analysis. The report was reviewed by Dr. Peveril Meigs, Dr. Llewelyn Williams, and Dr. William Porter. The tables were typed by Miss Carol Christensen. Cartography was performed by Miss Pernel Leuvelink under the supervision of Mr. Aubrey Greenwald.

FREQUENCY DISTRIBUTION BY MONTHS OF DAILY INSOLATION

Yuma Test Station, Arizona, 20 October 1951 - 31 March 1962

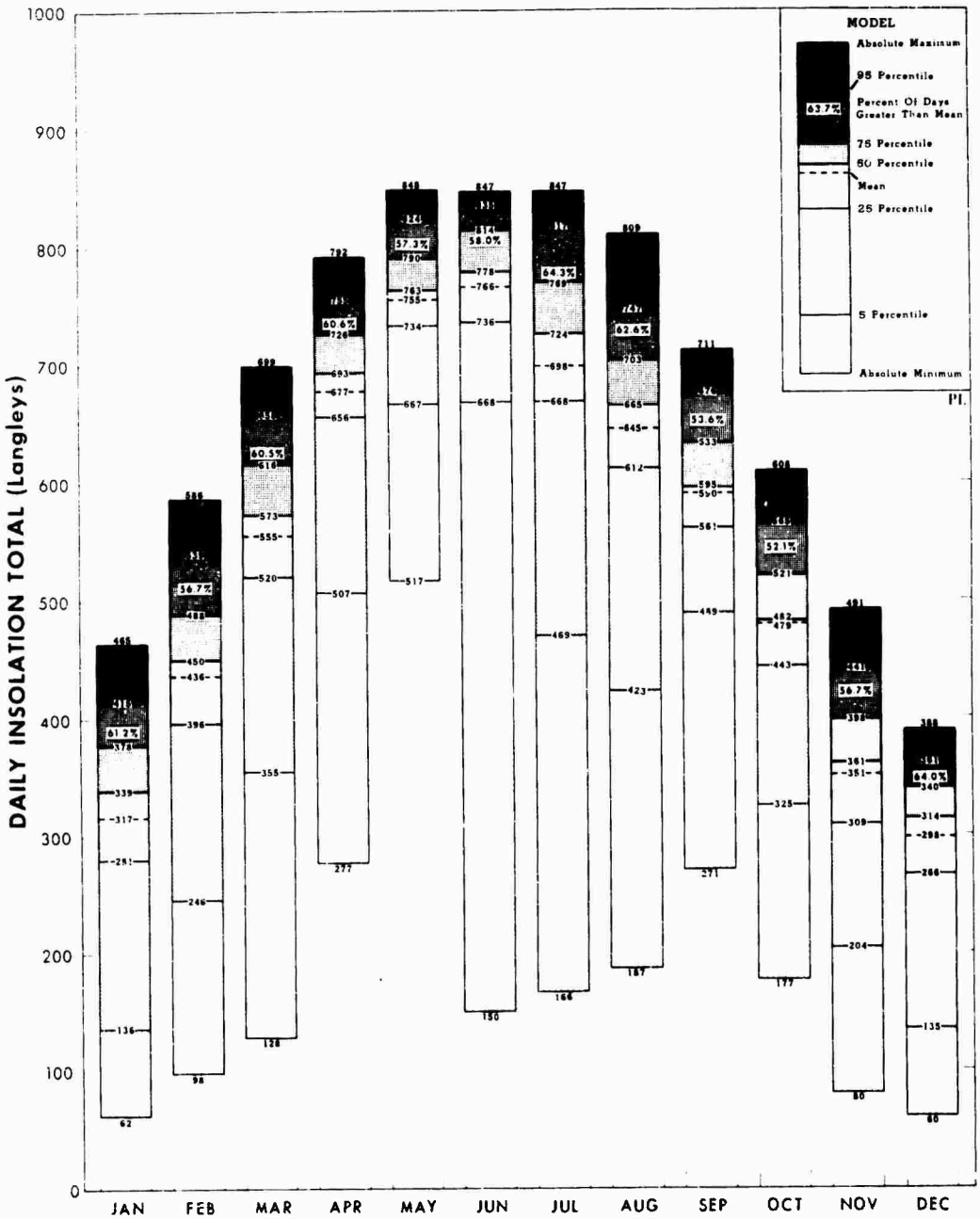


Figure 9

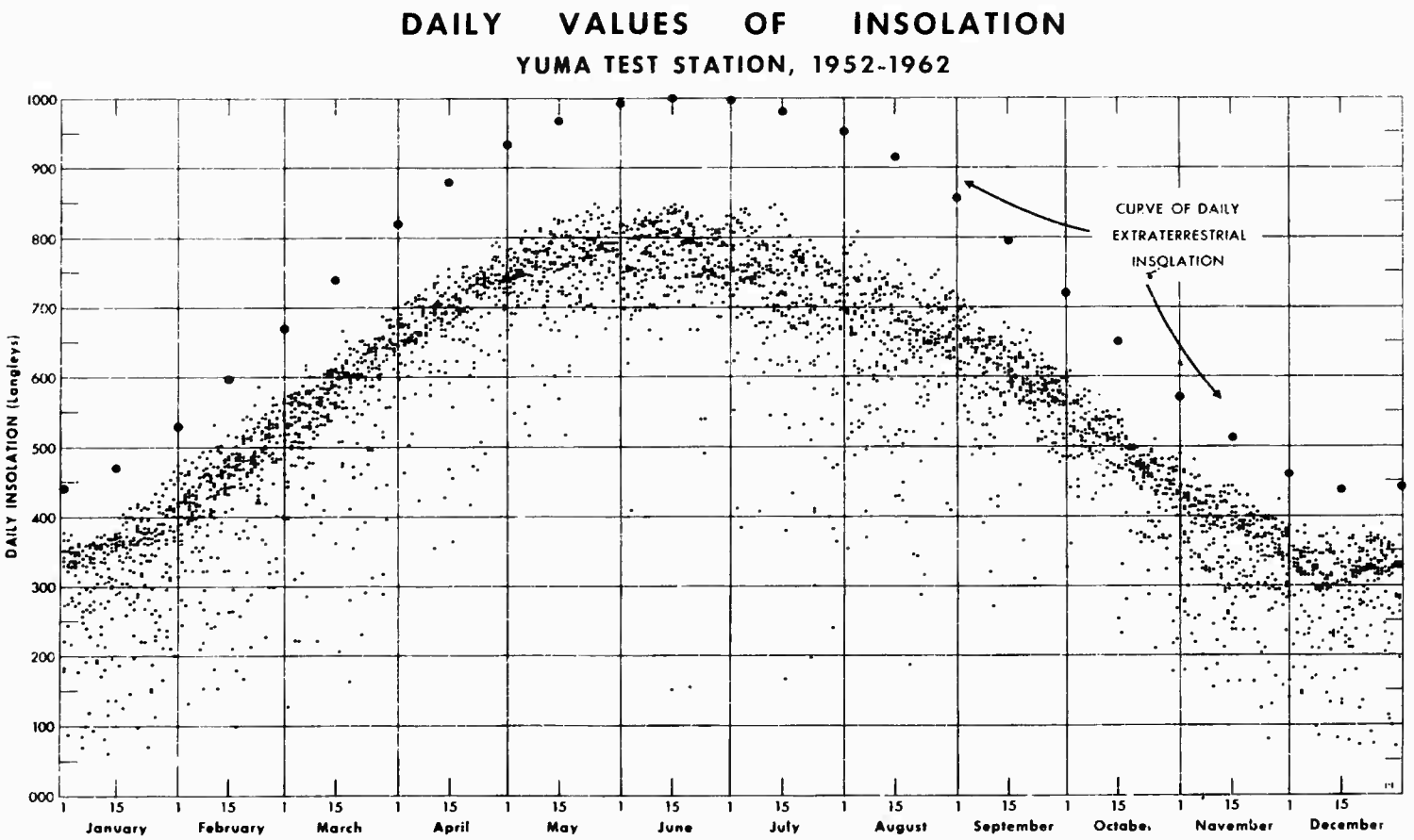

DAILY VALUES OF INSOLATION
YUMA TEST STATION, 1952-1962
DAILY INSOLATION (Langleys)
1000
900
800
700
600
500
400
300
200
100
000
CURVE OF DAILY
EXTRATERRESTRIAL
INSOLATION
1
15
January
February
March
April
May
June
July
August
September
Octabe.
November
December

Figure 10

6. References

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APPENDIX

Frequency Distribution of Hourly Insolation for Each Month of the Year

Table II - October 1951 through September 1958

Table III - October 1958 through March 1962

TABLE II

FREQUENCY DISTRIBUTIONS OF HOURLY INSOLATION FOR EACH MONTH OF YEAR
Yuma Test Station, Arizona
October 1951 through September 1958
(Hours based on Mountain Standard Time)

a. January (1952-1958)

Class Intervals in Langleys

Hour Ending		0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79
06									
07									
08	74	74 100.0							
09	182	74 40.7	108 59.3						
10	183	13 7.1	29 15.8	92 50.3	49 26.8				
11	183	3 1.6	19 10.4	15 8.2	43 23.5	91 49.7	12 6.6		
12	183	4 2.2	6 3.3	15 8.2	19 10.4	27 14.8	86 47.0	26 14.2	
13	183	2 1.1	8 4.4	13 7.1	13 7.1	26 14.2	66 36.1	51 27.9	4 2.2
14	183	1 0.6	8 4.4	15 8.2	16 8.7	30 16.4	67 36.6	42 23.0	4 2.2
15	183	3 1.6	15 2.2	21 11.5	27 14.8	44 39.0	64 35.0	9 4.9	
16	183	12 6.6	23 12.6	35 19.1	66 36.1	46 25.1	1 0.6		
17	183	23 12.6	76 41.5	79 43.2	5 2.7				
18	172	160 93.0	12 7.0						
19	10	10 100.0							
20									
21									
Totals	1,902	379	304	285	238	264	296	128	8
% Freq.		19.9	16.0	15.0	12.5	13.9	15.6	6.7	0.4
Cum. % Freq.		100.0	80.1	64.1	49.1	36.6	22.7	7.1	0.4

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

b. February (1952-1958)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89
06										
07										
08	168	168								
		100.0								
09	185	25	103	57						
		13.5	55.7	30.8						
10	185	2	10	21	96	56				
		1.1	5.4	11.4	51.9	30.3				
11	185		5	8	7	37	102	26		
			2.7	4.3	3.8	20.0	55.1	14.1		
12	185	2	2	3	4	13	13	111	37	
		1.1	1.1	1.6	2.2	7.0	7.0	60.0	20.0	
13	185		3	2	4	9	10	52	102	3
			1.6	1.1	2.2	4.9	5.4	28.1	55.1	1.6
14	185		4	2	4	9	19	50	93	4
			2.2	1.1	2.2	4.9	10.3	27.0	50.3	2.2
15	185	1	3	6	3	10	41	103	18	
		0.5	1.6	3.2	1.6	5.4	22.2	55.7	9.7	
16	185	1	7	7	20	65	79	6		
		0.5	3.8	3.8	10.8	35.1	42.7	3.2		
17	185	5	12	52	103	13				
		2.7	6.5	28.1	55.7	7.0				
18	185	46	128	11						
		24.9	69.2	5.9						
19	131	130	1							
		99.2	0.8							
20										
21										
Totals	2,149	380	278	169	241	212	264	348	250	7
% Freq.		17.7	12.9	7.9	11.2	9.9	12.3	16.2	11.6	0.3
Cum. % Freq.		100.0	82.3	69.4	61.5	50.3	40.4	28.1	11.9	0.3

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

c. March (1952-1958)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
06											
07	50	50 100.0									
08	185	106 57.3	74 40.0	5 2.7							
09	187	7 3.7	23 12.3	66 35.3	83 44.4	8 4.3					
10	187	1 0.5	7 3.7	10 5.3	15 8.0	62 33.2	81 43.3	10 5.3	1 0.5		
11	187	1 0.5	2 1.1	3 1.6	5 2.7	8 4.3	15 3.0	98 52.4	54 28.9	1	
12	187		3 1.6	1 0.5	3 1.6	4 2.1	11 5.9	11 5.9	107 57.2	46 24.6	1 0.5
13	187		2 1.1	2 1.1	5 2.7		9 4.8	11 5.9	46 24.6	99 52.9	13 7.0
14	187		3 1.6	4 2.1	3 1.6	7 3.7	7 3.7	13 7.0	53 28.3	90 48.1	7 3 7
15	187		2 1.1	9 4.8	4 2.1	8 4.3	10 5.3	28 15.0	112 59.9	14 7.5	
16	187		2 1.1	10 6.4	12 8.6	16 27.8	52 49.2	92 1.6	3		
17	187	3 1.6	10 5.3	18 9.6	46 24.6	103 55.1	7 3.7				
18	187	14 7.5	68 36.4	100 53.5	5 2.7						
19	180	177 98.3	3 1.7								
20											
21											
Totals	2,285	359	199	228	181	216	198	263	376	250	21
% Freq.		15.7	8.7	10.0	7.9	9.5	8.4	11.5	16.5	10.9	0.9
Cum. % Freq.		100.0	84.3	75.6	65.6	57.7	48.2	29.8	28.3	11.8	0.9

NOTE. OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

d. April (1952-1958)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109
06	2	2 100.0										
07	257	247 96.1	10 3.9									
08	260	6 2.3	75 28.8	169 65.0	10 3.8							
09	260		6 2.3	14 5.4	45 17.3	179 68.8	16 6.2					
10	260		2 0.8	4 1.5	12 4.6	8 3.1	43 16.5	184 70.7	7 2.7			
11	260		1 0.4		3 1.2	7 2.7	5 1.9	13 5.0	176 67.7	55 21.2		
12	260			1 0.4	3 1.2	4 1.5	3 1.2	4 1.5	7 2.7	199 76.5	39 15.0	
13	260				3 1.2	2 0.8	3 1.2	5 1.9	2 0.8	74 28.5	169 65.0	2 0.8
14	260			1 0.4	2 0.8	5 1.9	6 2.3	2 0.8	9 3.5	119 45.8	116 44.6	
15	260		3 1.2		4 1.5	3 1.2	6 2.3	6 2.3	49 18.8	189 72.7		
16	260		5 1.9	2 0.8	6 2.3	6 2.3	21 8.1	126 48.5	94 36.2			
17	260		5 1.9	9 3.5	19 7.3	105 40.4	122 46.9					
18	260	4 1.5	23 8.8	152 58.5	81 31.2							
19	260	172 66.2	88 33.8									
20	36	36 100.0										
21												
Totals:	3,415	467	218	352	188	319	225	340	344	636	324	2
% Freq.		13.7	6.4	10.3	5.5	9.3	6.6	9.9	10.1	18.6	9.5	0.1
Cum. % Freq.		100.0	86.3	79.9	69.6	64.1	54.8	48.2	38.3	28.2	9.6	0.1

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

d. April (1952-1958)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109
06	2	2 100.0										
07	257	247 96.1	10 3.9									
08	260	6 2.3	75 28.8	169 65.0	10 3.8							
09	260		6 2.3	14 5.4	45 17.3	179 68.8	16 6.2					
10	260		2 0.8	4 1.5	12 4.6	8 3.1	43 16.5	184 70.7	7 2.7			
11	260		1 0.4		3 1.2	7 2.7	5 1.9	13 5.0	176 67.7	55 21.2		
12	260			1 0.4	3 1.2	4 1.5	3 1.2	4 1.5	7 2.7	199 76.5	39 15.0	
13	260				3 1.2	2 0.8	3 1.2	5 1.9	2 0.8	74 28.5	169 65.0	2 0.8
14	260			1 0.4	2 0.8	5 1.9	6 2.3	2 0.8	9 3.5	119 45.8	116 44.6	
15	260		3 1.2		4 1.5	3 1.2	6 2.3	6 2.3	49 18.8	189 72.7		
16	260		5 1.9	2 0.8	6 2.3	6 2.3	21 8.1	126 48.5	94 36.2			
17	260		5 1.9	9 3.5	19 7.3	105 40.4	122 46.9					
18	260	4 1.5	23 8.8	152 58.5	81 31.2							
19	260	172 66.2	88 33.8									
20	36	36 100.0										
21												
Totals:	3,415	467	218	352	188	319	225	340	344	636	324	2
% Freq.		13.7	6.4	10.3	5.5	9.3	6.6	9.9	10.1	18.6	9.5	0.1
Cum. % Freq.		100.0	86.3	79.9	69.6	64.1	54.8	48.2	38.3	28.2	9.6	0.1

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

e. May (1952-1958)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109
06	75	75 100.0										
07	207	83 40.1	124 47.7									
08	208	1 0.5	12 5.8	83 39.9	112 53.8							
09	208		1 0.5	5 2.4	5 2.4	70 33.6	123 59.1	4 1.9				
10	208			2 1.0	1 0.5	6 2.9	7 3.4	127 61.1	63 30.3	2 1.0		
11	208						4 1.9	4 1.9	42 30.3	153 73.6	5 2.4	
12	208					1 0.5		3 1.4	7 3.4	89 42.8	105 50.5	3 1.4
13	208			1 0.5			1 0.5	2 1.0	6 2.9	20 9.6	169 81.2	9 4.3
14	208					2 1.0	1 0.5	2 1.0	9 4.3	35 16.8	153 73.6	6 2.9
15	208				3 1.4	1 1.4	1 1.4	7 3.4	18 8.6	160 76.9	18 8.6	
16	208		1.0 0.5	3 1		4 1.9	5 2.4	38 18.3	153 73.6	4 1.9		
17	208		4 1.9	3 1.4	10 4.8	22 10.6	152 73.1	16 7.7		1 0.5		
18	208		13 6.3	35 16.8	144 69.2	16 7.7						
19	208	27 13.0	168 80.8	13 6.3								
20	169	169 100.0										
21	1	1 100.0										
Totals	2,948	346	323	145	275	122	294	203	298	464	450	18
% Freq.		12.1	11.0	4.9	9.3	4.1	10.0	6.9	10.1	15.7	15.3	0.6
Cum. % Freq.		100.0	87.9	76.9	72.0	62.7	58.6	48.6	41.7	31.6	15.9	0.6

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

f. June (1952-1958)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109
06	123	123 100.0										
07	200	40 20.0	157 78.5	3 1.5								
08	201	1 0.5	9 4.5	48 23.9	141 70.1	2 1.0						
09	201		1 0.5	6 3.0	6 3.0	58 28.8	127 63.2	3 1.5				
10	201		1 0.5	4 2.0	1 0.5	2 1.0	1 0.5	132 65.7	59 29.4	1 0.5		
11	201		2 1.0	1 0.5	1 0.5		2 1.0	4 2.0	85 42.3	105 52.2	1 0.5	
12	201		2 1.0	1 0.5		1 0.5	1 0.5		3 1.5	116 57.7	76 37.8	1 0.5
13	201		2 1.0		1 0.5	1 0.5	1 0.5	2 1.0	3 1.5	60 29.8	129 64.2	2 1.0
14	201	1 0.5		1 0.5		2 1.0	1 0.5	1 0.5	4 2.0	66 32.8	124 61.7	1 0.5
15	201	1 0.5	1 0.5			1 0.5	2 1.0	1 0.5	15 7.5	169 84.1	11 5.5	
16	201	2 1.0			1 0.5	3 1.5	2 1.0	26 12.9	165 82.1	2 1.0		
17	201	2 1.0		4 2.0	3 1.5	11 5.5	122 60.7	58 28.8	1 0.5			
18	201	2 1.0	4 2.0	11 5.5	126 62.7	57 28.4	1 0.5					
19	200	9 4.5	111 55.5	80 40.0								
20	196	194 99.0	2 1.0									
21	2	2 100.0										
Totals	2,932	377	292	159	280	138	260	227	335	519	341	4
% Freq.		12.9	10.0	5.4	9.6	4.7	8.9	7.7	11.4	17.7	11.6	0.1
Cum. % Freq.		100.0	87.1	77.1	71.7	62.1	57.4	48.5	40.8	29.4	11.7	0.1

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

g. July (1952-1958)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109
06	44	44 100.0										
07	201	141 70.2	59 29.4	1 0.5								
08	202	9 4.5	27 13.4	131 64.9	34 16.8	1 0.5						
09	202	4 2.0	8 4.0	13 6.4	24 11.9	115 56.9	38 18.8					
10	202	1 0.5	4 2.0	5 2.5	7 3.5	12 5.9	21 10.4	141 69.8	11 5.4			
11	202	1 0.5		5 2.5	4 2.0	3 1.5	6 3.0	9 4.5	145 71.8	14.4		
12	202	1 0.5	2 1.0	2 1.0	4 2.0	4 2.0	3 1.5	2 1.0	9 4.5	151 74.6	24 11.9	
13	202	2 1.0	2 1.0	5 2.5	1 0.5	2 1.0	1 0.5	8 4.0	7 3.5	97 48.0	75 37.1	2 1.0
14	202		5 2.5		4 2.0	2 1.0	2 1.0	5 2.5	6 3.0	111 55.0	67 33.2	
15	202	2 1.0	4 2.0	2 1.0	2 1.0	1 0.5	4 2.0	2 1.0	38 18.8	138 68.3	9 4.5	
16	202	1 0.5	2 1.0	3 1.5	1 0.5	6 3.0	9 4.5	46 22.8	130 64.4	4 2.0		
17	202		4 2.0	6 3.0	10 5.0	20 9.9	135 66.8	26 12.9	1 0.5			
18	202	3 1.5	11 5.4	17 8.4	137 67.8	34 16.8						
19	201	25 12.4	132 65.7	44 21.9								
20	194	194 100.0										
21	1	1 100.0										
Totals:	2,863	429	260	234	228	200	219	239	347	530	175	2
% Freq.		15.0	9.1	8.2	8.0	7.0	7.6	8.3	12.3	18.5	6.1	0.1
Cum. % Freq.		100.0	85.0	75.9	67.7	59.7	52.7	45.1	36.8	24.7	6.2	0.1

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

h. August (1952-1958)

Class Intervals in Langleys

Hours Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
06											
07	204	199 97.5	5 2.4								
08	207	11 5.3	70 33.8	126 60.9							
09	207	2 1.0	4 2.0	12 5.8	66 31.9	123 59.4					
10	207	2 1.0	2 1.0	5 2.4	8 3.9	15 7.3	81 39.1	94 45.4			
11	207	2 1.0		2 1.0	1 0.5	5 2.4	13 6.3	26 12.6	147 71.0	11 5.3	
12	207		2 1.0	1 0.5		3 1.4	9 4.4	11 5.3	41 19.8	130 62.8	10 4.8
13	207			3 1.4	1 0.5	4 2.0	3 1.4	13 6.3	22 10.7	124 59.9	37 17.9
14	207			2 1.0		6 2.9	6 2.9	11 5.3	20 9.7	140 67.6	22 10 6
15	207		1 0.5	1 0.5	2 1.0	3 1.4	14 6.8	15 7.3	95 45.9	75 36.2	1 0.5
16	207	1 0.5	2 1.0	2 1.0	7 3.4	12 5.8	22 10.6	110 53.1	51 24.6		
17	207	1 0.5	4 1.9	13 6.3	17 8.2	84 40.6	80 38.6	8 3.9			
18	207	5 2.4	13 6.3	90 43.4	92 44.4	7 3.4					
19	203	76 37.4	120 59.1	7 3.4							
20	130	130 100.0									
21											
Totals:	2,814	429	223	264	194	262	228	288	376	480	70
% Freq.		15.2	7.9	9.4	6.9	9.3	8.1	10.2	13.4	17.1	2.5
Cum. % Freq.		100.0	84.8	76.9	67.5	60.6	51.3	43.2	33.0	19.6	2.5

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

1. September (1952-1958)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
06											
07	187	187 100.0									
08	203	8 3.9	165 81.3	30 14.8							
09	203	1 0.5	5 2.5	10 4.9	157 77.3	30 14.8					
10	203			1 0.5	2 1.0	26 12.3	156 76.8	18 8.9			
11	203					2 1.0	11 5.4	99 48.8	91 44.8		
12	203						3 1.5	19 9.4	110 54.2	71 35.0	
13	203				1 0.5	2 1.0	2 1.0	10 4.9	63 31.0	121 59.6	4 2.0
14	203				3 1.5	1 0.5	5 2.5	18 8.9	87 42.8	89 43.8	
15	203		1 0.5	1 0.5	3 1.5	1 0.5	12 5.9	66 32.5	115 56.6	4 2.0	
16	203		3 1.5	2 1.0	2 1.0	23 11.3	109 53.7	63 31.0	1 0.5		
17	203	3 1.5	2 1.0	14 6.9	99 48.8	81 39.9	4 2.0				
18	202	6 3.0	103 51.0	88 43.6	5 2.5						
19	193	185 95.8	8 4.1								
20	9	9 100.0									
21											
Totals	2,621	399	287	146	272	166	302	293	467	285	4
% Freq.		15.2	10.9	5.6	10.4	6.3	11.5	11.2	17.8	10.9	0.2
Cum. % Freq.		100.0	84.8	73.9	68.3	57.9	51.6	40.1	28.9	11.1	0.2

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

j. October (1951-1957)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89
06	1	1 100.0								
07	46	46 100.0								
08	147	61 41.5	84 57.1	2 1.4						
09	147		6 4.1	73 49.7	66 44.9	2 1.4				
10	147	1 0.7	3 2.0	5 3.4	18 12.2	82 55.8	37 25.2	1 0.7		
11	147		1 0.7	3 2.0		16 10.9	30 20.4	91 61.9	6 4.1	
12	147			3 2.0	2 1.4	6 4.1	9 6.1	41 27.9	83 56.5	3 2.0
13	147			2 1.4	2 1.4	2 1.4	14 9.5	14 9.5	99 67.4	14 9.5
14	147		1 0.7	2 1.4	4 2.7	6 4.1	14 9.5	42 28.6	76 51.7	2 1.4
15	147		2 1.4		3 2.0	19 12.9	42 28.6	75 51.0	6 4.1	
16	147	1 0.7	4 2.7	6 4.1	30 20.4	85 59.8	20 13.6	1 0.7		
17	147	3 2.0	25 17.0	83 56.5	35 23.8	1 0.7				
18	144	86 59.7	57 39.6	1 0.7						
19	36	36 100.0								
20										
21										
Totals	1,697	235	183	180	160	219	166	265	270	19
% Freq.		13.9	10.8	10.6	9.4	12.9	9.8	15.6	15.9	1.1
Cum. % Freq.		100.0	86.1	75.3	64.7	55.3	42.4	32.6	17.0	1.1

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

k. November (1951-1957)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79
06									
07	1	1 100.0							
08	183	177 96.7	6 3.3						
09	186	9 4.8	86 46.2	89 47.8	2 1.1				
10	186	4 2.2	9 4.8	14 7.5	109 58.6	50 26.9			
11	186	1 0.5	5 2.7	8 4.3	10 5.4	75 40.3	84 45.2	3 1.6	
12	186		4 2.2	4 2.2	10 5.4	42 22.6	50 26.9	75 40.3	1 0.5
13	186		2 1.1	6 3.2	9 4.8	39 21.0	32 17.2	90 48.4	8 4.3
14	186		3 1.6	5 2.7	12 6.4	48 25.8	49 26.3	68 36.6	1 0.5
15	186	1 0.5	6 3.2	9 4.8	38 20.4	71 38.2	60 32.2	1 0.5	
16	186	2 1.1	15 8.1	49 26.3	107 57.5	12 6.4	1 0.5		
17	186	21 11.3	133 71.5	31 16.7	1 0.5				
18	174	173 99.4	1 0.6						
19									
20									
21									
Totals	2,032	389	270	215	298	337	276	237	10
% Freq.		19.1	13.3	10.6	14.7	16.6	13.6	11.6	0.5
Cum. % Freq.		100.0	80.9	67.6	57.0	42.3	25.7	12.1	0.5

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE II (Cont.)

1. December (1951-1957)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79
06									
07									
08	143	143 100.0							
09	191	59 30.9	126 66.0	6 3.1					
10	191	7 3.7	25 13.1	85 44.5	74 38.7				
11	191	4 2.1	6 3.1	22 11.5	34 17.8	118 61.8	7 3.7		
12	191	2 1.0	9 4.7	9 4.7	16 8.4	43 22.5	103 53.9	8 4.2	1 0.5
13	191		10 5.2	6 3.1	18 9.4	37 19.4	96 50.3	20 10.5	4 2.1
14	191	1 0.5	10 5.2	10 5.2	18 9.4	37 19.4	106 55.5	8 4.2	1 0.5
15	191	3 1.6	14 7.3	16 8.4	36 18.8	109 57.1	12 6.3	1 0.5	
16	191	9 4.7	23 12.0	69 36.1	82 42.9	7 3.9	1 0.5		
17	191	46 24.1	125 65.4	20 10.5					
18	175	175 100.0							
19	1	1 100.0							
20									
21									
Totals	2,038	450	348	243	278	351	325	37	6
% Freq.		22.1	17.1	11.9	13.6	17.2	16.0	1.8	0.3
Cum. % Freq.		100.0	77.9	60.8	48.9	35.3	18.1	2.1	0.3

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III

FREQUENCY DISTRIBUTIONS OF HOURLY INSOLATION FOR EACH MONTH OF THE YEAR
Yuma Test Station, Arizona
October 1958 through March 1962
(Hours Based on True Solar Time)

a. January (1959-1962)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69
06								
07								
08	114	114 100.0						
09	122	20 16.4	98 80.3	4 3.3				
10	122	2 1.6	15 12.3	21 17.2	84 68.8			
11	122	3 2.5	1 0.8	11 9.0	10 8.2	91 74.6	6 4.9	
12	122		5 4.1	6 4.9	7 5.7	8 6.6	92 75.4	4 3.3
13	122		7 5.7	1 0.8	4 3.3	11 9.0	66 54.1	33 27.1
14	122	4 3.3	3 2.5	2 1.6	6 4.9	10 8.2	88 72.1	9 7.4
15	122	2 1.6	3 2.5	5 4.1	16 13.1	77 63.1	18 14.8	1 0.8
16	122	4 3.3	10 8.2	32 26.2	72 59.0	4 3.3		
17	122	21 17.2	85 69.7	16 13.1				
18	106	106 100.0						
19								
20								
21								
Totals:	1,318	276	227	98	199	201	270	47
% Freq.		20.9	17.2	7.4	15.1	15.3	20.5	3.6
Cum. % Freq.		100.0	79.1	61.9	54.5	39.4	24.1	3.6

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

b. February (1959-1962)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89
06										
07										
08	111	109 98.2	2 1.8							
09	120	7 5.8	61 50.8	52 43.3						
10	120	2 1.7	7 5.8	19 15.8	53 44.2	39 32.5				
11	120		4 3.3	11 9.2	6 5.0	21 17.5	65 54.2	13 10.8		
12	120	1 0.8	2 1.7	5 4.2	7 5.8	9 7.5	19 15.8	63 52.5	14 11.7	
13	120		1 0.8	8 6.7	5 4.2	6 5.0	13 10.8	48 40.0	38 31.7	1 0.8
14	120	1 0.8	2 1.7	6 5.0	3 2.5	10 8.3	10 8.3	60 50.0	28 23.3	
15	120	1 0.8	3 2.5	4 3.3	10 8.3	14 11.7	49 40.8	36 30.0	3 2.5	
16	120	2 1.7	5 4.2	14 11.7	17 14.2	68 56.7	14 11.7			
17	120	6 5.0	24 20.0	62 51.7	28 23.3					
18	119	81 68.1	38 31.9							
19	30	30 100.0								
20										
21										
Totals:	1,340	240	149	181	129	167	170	220	83	1
% Freq.		17.9	11.1	13.5	9.6	12.5	12.7	16.4	6.2	0.1
Cum. % Freq.		100.0	82.1	71.0	57.5	47.9	35.4	22.7	6.3	0.1

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

c. March (1959-1962)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
06											
07	45	45 100.0									
08	90	32 35.6	48 53.3	10 11.1							
09	90	1 1.1	3 3.3	31 34.4	43 47.8	12 13.3					
10	90	1 1.1	1 1.1	3 3.3	7 7.8	24 26.7	45 50.0	9 10.0			
11	90		1 1.1	2 2.2	2 2.2	1 1.1	6 6.7	49 54.4	29 32.2		
12	90				2 2.2	3 3.3	1 1.1	6 6.7	58 64.4	20 22.2	
13	90			1 1.1	1 1.1	1 1.1	2 2.2	8 8.9	27 30.0	49 54.4	1 1.1
14	90			1 1.1		4 4.4	2 2.2	4 4.4	38 42.2	41 45.6	
15	90		1 1.1	1 1.1	3 3.3	4 4.4	6 6.7	23 25.6	52 57.8		
16	90	1 1.1		3 3.3	3 3.3	13 14.4	60 66.7	9 10.0	1 1.1		
17	90	1 1.1	5 5.6	15 16.7	59 65.6	10 11.1					
18	90	14 15.6	67 74.4	9 10.0							
19	81	81 100.0									
20											
21											
Totals:	1,116	176	126	76	120	72	122	108	205	110	1
% Freq.		15.8	11.3	6.8	10.8	6.4	10.9	9.7	18.4	9.8	0.1
Cum. % Freq.		100.0	84.2	72.9	66.1	55.3	48.9	38.0	28.3	9.9	0.1

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

d. April (1959-1961)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109
06	22	22 100.0										
07	89	53 59.6	36 40.4									
08	89	1 1.1	10 11.2	42 47.2	36 40.4							
09	89			4 4.5	4 4.5	45 50.6	36 40.4					
10	89				2 2.2	4 4.5	5 5.6	54 60.7	24 27.0			
11	89					2 2.2	2 2.2	2 2.2	44 49.4	39 43.8		
12	89				1 1.1	1 1.1	3 3.4	2 2.2	4 4.5	63 70.8	15 16.8	
13	89							3 3.4	4 4.5	54 60.7	27 30.3	1 1.1
14	89					1 1.1	2 2.2	10 11.2	8 9.0	68 76.4		
15	89				2 2.2	4 4.5	4 4.5	8 9.0	70 78.6	1 1.1		
16	89			3 3.4	4 4.5	3 3.4	43 48.3	36 40.4				
17	89	1 1.1	3 3.4	3 3.4	44 49.4	37 41.6		1 1.1				
18	89	2 2.2	53 59.6	34 38.2								
19	89	89 100.0										
20												
21												
Totals:	1,179	168	102	86	93	97	95	116	154	225	42	1
% Freq.		14.2	8.6	7.3	7.9	8.2	8.1	9.8	13.1	19.1	3.6	0.1
Cum. % Freq.		100.0	85.8	77.2	69.9	62.0	53.8	45.7	35.9	22.9	3.7	0.1

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

e. May (1959-1961)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109
06	83	83 100.0										
07	85	1 1.2	73 85.9	11 12.9								
08	85		1 1.2	4 4.7	60 70.6	20 22.5						
09	85			1 1.2	1 1.2	4 4.7	58 68.2	21 24.7				
10	85				1 1.2		1 1.2	16 18.8	65 76.5	2 2.4		
11	85							3 3.5	10 11.8	57 67.1	15 17.6	
12	85							1 1.2	2 2.4	38 44.7	43 50.6	1 1.2
13	85						2 2.4	1 1.2	1 1.2	23 27.1	50 58.8	8 9.4
14	85						2 2.4	3 3.5	2 2.4	55 64.7	23 27.1	
15	85				1 1.2	1 1.2	1 1.2	2 2.4	49 57.6	31 36.5		
16	85				1 1.2	2 2.4	12 14.1	69 81.2	1 1.2			
17	85			4 4.7	10 11.8	70 82.4	1 1.2					
18	85	2 2.4	12 14.1	71 83.5								
19	84	84 100.0										
20	1	1 100.0										
21												
Totals:	1,188	171	86	91	74	97	77	116	130	206	131	9
% Freq.		14.4	7.2	7.7	6.2	8.2	6.5	9.8	10.9	17.3	11.0	0.8
Cum. % Freq.		100.0	85.6	78.4	70.7	64.5	56.3	49.8	40.0	29.1	11.8	0.8

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

f. June (1959-1961)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109
06	85	85 100.0										
07	86	3 3.5	70 81.4	13 15.1								
08	86		1 1.2	2 2.3	69 80.2	14 16.3						
09	86			1 1.2	1 1.2	5 5.8	68 79.1	11 12.8				
10	86					1 1.2	2 2.3	27 31.4	56 65.1			
11	86			1 1.2				1 1.2	19 22.1	62 72.1	3 3.5	
12	86				1 1.2			1 1.2	4 4.6	49 57.0	31 36.0	
13	86					1 1.2	1 1.2	2 2.3		38 44.2	38 44.2	6 7.0
14	86						2 2.3	3 3.5	1 1.2	52 60.5	28 32.6	
15	86					1 1.2	2 2.3	1 1.2	47 54.6	35 40.7		
16	86			1 1.2		2 2.3	5 5.8	64 74.4	14 16.3			
17	86			2 2.3	6 7.0	45 52.3	33 38.4					
18	86	3 3.5	3 3.5	50 58.1	30 34.9							
19	86	42 48.8	44 51.2									
20	51	51 100.6										
21												
Totals:	1,254	184	118	70	107	69	113	110	141	236	100	6
% Freq.		14.7	9.4	5.6	8.5	5.5	9.0	8.8	11.2	18.8	8.0	0.5
Cum. % Freq.		100.0	85.3	75.9	70.3	61.8	56.3	47.3	38.5	27.3	8.5	0.5

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

g. July (1959-1961)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109
06	64	64 100.0										
07	93	32 34.4	61 65.6									
08	93	5 5.4	9 9.7	35 37.6	44 47.3							
09	93	2 2.2	6 6.4	7 7.5	6 6.4	34 36.6	38 40.9					
10	93		1 1.1	6 6.4	5 5.4	2 2.2	10 10.8	55 59.1	14 15.1			
11	93			4 4.3	1 1.1	4 4.3	5 5.4	3 3.2	48 51.6	28 30.1		
12	93			2 2.2	3 3.2	2 2.2	4 4.3		4 4.3	54 58.1	24 25.8	
13	93			1 1.1	1 1.1	2 2.2	3 3.2		7 7.5	48 51.6	30 32.3	1 1.1
14	93			1 1.1	1 1.1	1 1.1	5 5.4	3 3.2	4 4.3	55 59.1	23 24.7	
15	93		1 1.1		1 1.1	1 1.1	2 2.2	7 7.5	52 55.9	29 31.2		
16	93			1 1.1	2 2.2	1 1.1	8 8.6	68 73.1	12 12.9	1 1.1		
17	93			4 4.3	5 5.4	50 53.8	34 36.6					
18	93	1 1.1	9 9.7	50 53.8	33 35.5							
19	93	36 38.7	57 61.3									
20	65	65 100.0										
21												
Totals:	1,338	205	144	111	102	97	109	136	141	215	77	1
% Freq.		15.3	10.8	8.3	7.6	7.2	8.1	10.2	10.5	16.1	5.8	0.1
Cum. % Freq.		100.0	84.7	73.9	65.6	58.0	50.8	42.7	32.5	22.0	5.9	0.1

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

h. August (1959-1961)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
06	9	9 100.0									
07	93	80 86.0	13 14.0								
08	93	6 6.4	14 15.1	67 72.0	6 6.4						
09	93	3 3.2	5 5.4	6 6.4	11 11.8	63 67.7	5 5.4				
10	93		2 2.2	6 6.4	4 4.3	5 5.4	18 19.4	58 62.4			
11	93		2 2.2	1 1.1	2 2.2	2 2.2	5 5.4	10 10.8	55 59.1	16 17.2	
12	93			1 1.1		4 4.3	5 5.4	5 5.4	19 20.4	50 53.8	9 9.7
13	93			1 1.1	1 1.1	1 1.1	4 4.3	1 1.1	11 11.8	54 58.1	20 21.5
14	93		1 1.1	1 1.1		3 3.2	3 3.2	6 6.4	18 19.4	48 51.6	13 14.0
15	93			2 2.2	4 4.3	6 6.4	2 2.2	9 9.7	56 60.2	14 15.1	
16	93	1 1.1	2 2.2	2 2.2	4 4.3	5 5.4	33 35.5	44 47.3	2 2.2		
17	93	3 3.2	4 4.3	4 4.3	24 25.8	50 53.8	6 6.4	1 1.1	1 1.1		
18	93	10 10.8	26 28.0	55 59.1	2 2.2						
19	92	87 94.6	5 5.4								
20	6	6 100.0									
21											
Totals:	1,223	205	74	146	58.	139	81	134	162	182	42
% Freq.		16.8	6.1	11.9	4.7	11.4	6.6	11.0	13.2	14.9	3.4
Cum. % Freq.		100.0	83.2	77.1	65.2	60.5	49.1	42.5	31.5	18.3	3.4

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

1. September (1959-1961)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
06											
07	88	86 97.7	2 2.3								
08	89		7 7.9	81 91.0	1 1.1						
09	89		2 2.2	2 2.2	3 3.4	78 87.6	4 4.5				
10	89			1 1.1	1 1.1	3 3.4	18 20.2	65 73.0	1 1.1		
11	90		1 1.1		1 1.1	1 1.1	1 1.1	5 5.6	75 83.3	6 6.7	
12	90	1 1.1		1 1.1		1 1.1			44 48.9	41 45.6	2 2.2
13	89	1 1.1		1 1.1	1 1.1	2 2.2		1 1.1	43 48.3	33 37.1	7 7.9
14	89	1 1.1	1 1.1		2 2.2	1 1.1		2 2.2	60 67.4	21 23.6	1 1.1
15	89		1 1.1	2 2.2		2 2.2	11 12.4	52 58.4	20 22.5	1 1.1	
16	90		3 3.3	3 3.3	1 1.1	47 52.2	30 33.3	6 6.7			
17	89	2 2.2	8 9.0	44 49.4	28 31.5	6 6.7	1 1.1				
18	89	45 50.6	42 47.2	1 1.1	1 1.1						
19	39	38 97.4	1 2.6								
20	1	1 100.0									
21											
Totals:	1,111	175	6[illegible]	136	39	141	66	131	243	102	10
% Freq.		15.8	6.1	12.2	3.5	12.7	[illegible].9	11.8	21.9	9.2	0.9
Cum. % Freq.		100.0	84.2	78.1	65.9	62.4	49.7	43.8	32.0	10.1	0.9

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

j. October (1958-1961)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89
06										
07	118	118 100.0								
08	124	9 7.3	53 42.7	62 50.0						
09	124		8 6.4	4 3.2	56 45.2	56 45.2				
10	124		1 0.8	3 2.4	3 2.4	18 14.5	85 68.6	14 11.3		
11	124		1 0.8	1 0.8	3 2.4	3 2.4	11 8.9	76 61.3	29 23.4	
12	124			3 2.4		1 0.8	7 5.6	42 33.9	66 53.2	5 4.0
13	124	1 0.8		3 2.4	3 2.4	2 1.6	8 6.4	46 37.1	58 46.8	3 2.4
14	124		1 0.8	4 3.2	3 2.4	4 3.2	32 25.8	65 52.4	15 12.1	
15	124	2 1.6	4 3.2	1 0.8	9 7.3	55 44.4	47 37.9	6 4.8		
16	124	3 2.4	8 6.4	35 28.2	65 52.4	13 10.5				
17	124	30 24.2	81 65.3	13 10.5						
18	85	84 98.8	1 1.2							
19	3	3 100.0								
20										
21										
Totals:	1,446	250	158	129	142	152	190	249	168	8
% Freq.		17.3	10.9	8.9	9.8	10.5	13.2	17.2	11.6	0.6
Cum. % Freq.		100.0	82.7	71.8	62.9	53.1	42.6	29.4	12.2	0.6

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

k. November (1958-1961)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59	60-69
06								
07	65	65 100.0						
08	119	37 31.1	80 67.2	2 1.7				
09	119	7 5.9	12 10.1	47 39.5	52 43.7	1 0.8		
10	119	1 0.8	7 5.9	9 7.6	18 15.1	74 62.2	10 8.4	
11	119		1 0.8	7 5.9	10 8.4	14 11.8	73 61.3	14 11.8
12	119	1 0.8		4 3.4	9 7.6	8 6.7	51 42.9	46 38.7
13	119	1 0.8	1 0.8	6 5.0	8 6.7	9 7.6	60 50.4	34 28.6
14	119	1 0.8	5 4.2	8 6.7	6 5.0	38 31.9	61 51.3	
15	119	1 0.8	11 9.2	11 9.2	67 56.3	29 24.4		
16	119	9 7.6	50 42.0	60 50.4				
17	119	118 99.2	1 0.8					
18	3	3 100.0						
19								
20								
21								
Totals:	1,258	244	168	154	170	173	255	94
% Freq.		19.4	13.3	12.2	13.5	13.8	20.3	7.5
Cum. % Freq.		100.0	80.6	67.3	55.1	41.6	27.8	7.5

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

TABLE III (Cont.)

1. December (1958-1961)

Class Intervals in Langleys

Hour Ending	No. of Hours	0-9	10-19	20-29	30-39	40-49	50-59
06							
07	1	1 100.0					
08	115	113 98.3	2 1.7				
09	119	11 9.2	65 54.6	43 36.1			
10	119	4 3.4	8 6.7	20 16.8	81 68.1	6 5.0	
11	119	2 1.7	7 5.9	7 5.9	10 8.4	90 75.6	3 2.5
12	119	1 0.8	7 5.9	4 3.4	10 8.4	17 14.3	80 67.2
13	119		6 5.0	4 3.4	9 7.6	14 11.8	86 72.3
14	119		7 5.9	7 5.9	15 12.6	71 59.7	19 16.0
15	119	5 4.2	11 9.2	11 9.2	75 63.0	17 14.3	
16	119	11 9.2	27 22.7	81 68.1			
17	119	116 97.5	3 2.5				
18	6	6 100.0					
19							
20							
21							
Totals:	1,193	270	143	177	200	215	188
% Freq.		22.6	12.0	14.8	16.8	18.0	15.8
Cum. % Freq.		100.0	77.4	65.4	50.6	33.8	15.8

NOTE: OF THE PAIRED FIGURES IN THIS TABLE, THE UPPER REPRESENTS THE NUMBER OF HOURS; THE LOWER REPRESENTS THE PERCENT OF HOURS.

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3 REPORT TITLE

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5 AUTHOR(S) (Last name, first name, initial)

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10. AVAILABILITY/LIMITATION NOTICES

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Desert and Tropic Laboratory, Earth Sciences Division, U. S. Army Natick Laboratories, Natick, Mass.

13. ABSTRACT

Approximately 10 years of hourly and daily insolation data for the U. S. Army Yuma Test Station, Arizona, are summarized in tabular and graphical form. Frequency distributions, totals and means of hourly and daily insolation, are given for each month of the year.

The data were collected by an Eppley pyrheliometer (horizontal mount) and an electronic strip chart recorder. Integration and reduction of the data to numerical form were done visually. Information is presented concerning the efficiency of the Eppley pyrheliometer, and of the adequacy of visual data integration and reduction.

As expected from the latitude of the station (32°50'N) and the low incidence of cloud cover, insolation values are high throughout much of the year. From March through October, 30 percent or more of the hours receive at least 60 langleys, and from April through August, 20 percent of the hours receive 80 langleys or more. Intensities of 100 langleys or more occur from April through July, with the maximum during May when 3 percent of the 3 hours centered about True Solar Noon reach 100 langleys or more. Low values occur primarily during early morning, or late afternoon hours. Values less than 20 langleys do not occur at midday except on occasional days in winter and during the summer rainy period of late June and July.

Daily values also run high. Daily totals less than 100 langleys occur only in winter and then infrequently. From April through September, only 1.7 percent of the days have totals less than 400 langleys. On the other hand, 53 percent of the days of these same months receive 700 langleys or more.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Solar radiation	8					
Insolation	8					
Climatology	4					
Radiation measurement systems	10					
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